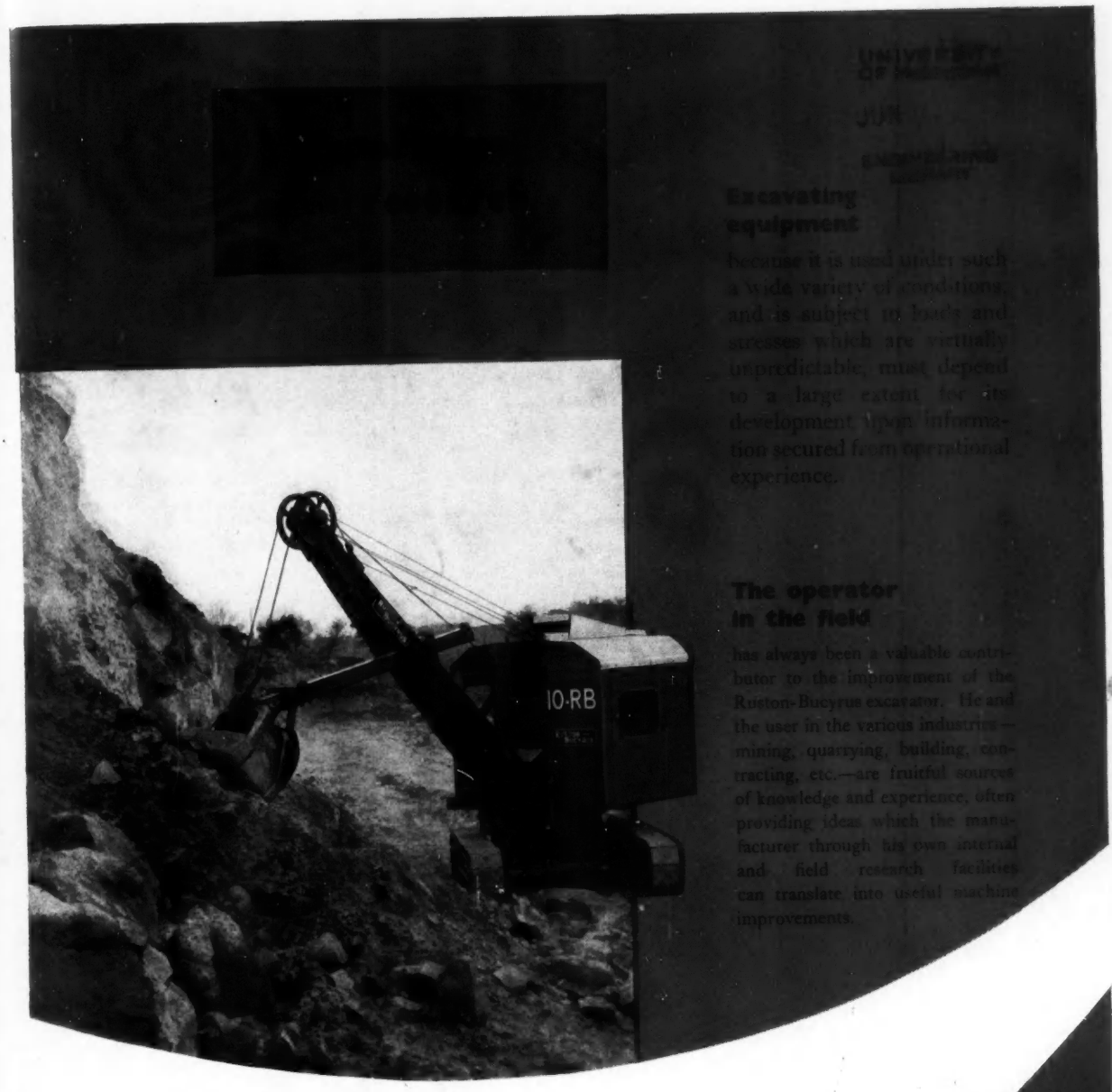
The Engineer

MAY 20, 1955 28, ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS



Excavating equipment

because it is used under such a wide variety of conditions, and is subject to loads and stresses which are virtually unpredictable, must depend to a large extent for its development upon information secured from operational experience.

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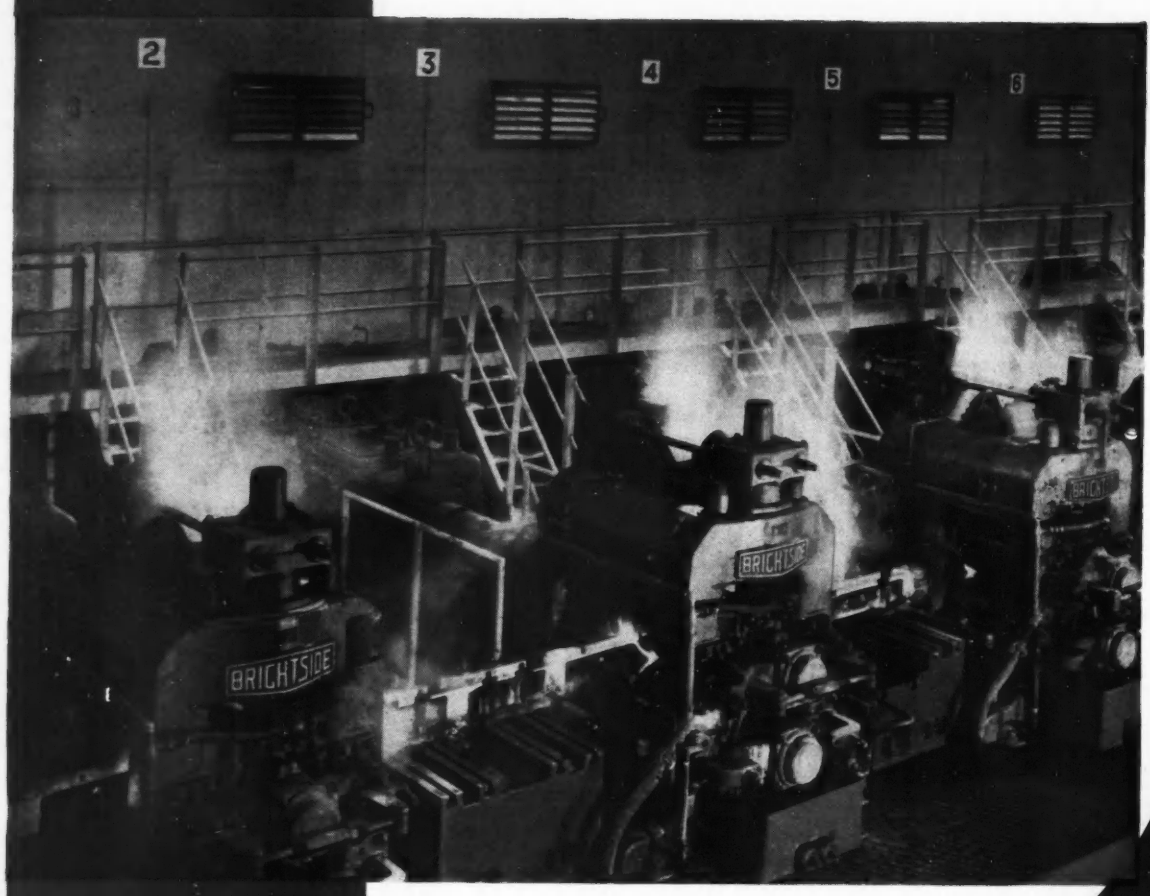

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Roughing Train of the Cont
(*Photograph by courtesy of*
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THE ENGINEER

MAY 20, 1955

Railway Electrification with Single-Phase Industrial Frequency Power

PROGRESS in railway electrification at 50 c/s 25kV, single-phase, between Valenciennes and Thionville was the subject of a four-day exposition at Lille, last week, which we attended at the invitation of French Railways. It may be recalled that an outline of this electrification scheme, with particular reference to the locomotives to be used, was given in papers read by Monsieur Garreau and Monsieur Nouvion at the Institution of Electrical Engineers on May 6, 1954 (*Proc. I.E.E.*, 131, Part I, 101, September, 1954). Electrification of 225 route miles between Valenciennes and Thionville requires six substations and 7 miles of h.v. feeder, compared with twenty-three substations and 211 miles of h.v. feeder for an equivalent d.c. system at 1500V. The total fixed equipment for 50 c/s working is expected to cost only 40 per cent of that for d.c. working. Two basic types of locomotives are in service: the first have C_0–C_0 bogies, weigh 120 tons, have a maximum speed of about 87 m.p.h., and are designed to haul goods trains of 1800 tons on gradients of 1 in 100. The second have B_0–B_0 bogies, weigh 80 tons, and are designed for mixed passenger and goods traffic and maximum speeds of 65 and 75 m.p.h. All the locomotives have only one driving cab. Of the C_0–C_0 locomotives about 75 per cent are fitted with single-phase/d.c. rotary converters and d.c. motors, and the remainder with phase and frequency converters and three-phase motors. Three-quarters of the B_0–B_0 motors are equipped with single-phase motors and the remainder with ignitrons and d.c. motors. Operating experience with these locomotives formed the basis of a number of papers presented at the Lille meeting. Monsieur Nouvion pointed out, for example, that the C_0–C_0 locomotives equipped with rotary converter sets were regularly starting and hauling trains of 1850 tonnes on gradients of 1 in 100, and that the B_0–B_0 locomotives were likewise capable of starting and hauling 1400-tonne trains on similar gradients. Visitors to the meeting saw these capabilities fully demonstrated under wet weather conditions on a 1 in 100 gradient near Querenaing. Future developments visualised by Monsieur Nouvion at this meeting included the introduction of high-speed, dual-frequency, B–B locomotives with excitrons feeding two d.c. traction motors—one per bogie; the possibility of single-phase, single-motor bogies was also envisaged.

Building Research in 1954

THE D.S.I.R.'s annual report on building research for the year 1954 has now been published by H.M. Stationery Office. The Building Research Board expresses the view that the building industry should give more direct financial support to the work of the Building Research Station than it does at present. The board recognises the diversity of the industry, but is also aware of the increasing demands the industry makes on the station. At the same time, the board welcomes the way in which member firms of the National Federation of Building Trades Employers are providing facilities for full-scale trials of new methods and materials. The report of the director of building research includes an outline of the trend, in structural engineering research, towards performance tests on complete structures to supplement and interpret laboratory studies of isolated parts of structures and of finding more economical design methods. Work in progress on multi-storey, steel-framed and prestressed concrete buildings and on bridges is described. Developments in technique include a means whereby the stress in a very small unit of material in an existing building—for example, in one brick, or in a block of stone—may be measured directly; this method has been used in examining masonry in the Victoria Tower of the Houses of Parliament. Dead-load stresses on bridges are not easy to determine in the laboratory because they are influenced by the constructional technique of the full-scale structure; the station took the opportunity of taking measurements during and after construction of a bridge to carry the Great North Road over the railway at Biggleswade. Strain measurements have continued on this bridge since it was finished to examine the change in dead-load stress with time. During 1954 observations were also made of the live-load stresses that occur when heavy vehicles pass over the bridge. The most valuable result has been the discovery that the strains in the steel girders have low values even for fairly heavy traffic. The data obtained have formed the basis for revised design methods. Other subjects mentioned in the report include a study of modular co-ordination, the cost of eight or ten-storey flats, the use of pulverised-fuel ash to make bricks, and an account of single-stack plumbing and the deterioration of ball valves due to cavitation.

Whitworth Fellowships and Prizes

THE Ministry of Education has published the rules and conditions for the award of Whitworth fellowships and prizes, under new arrangements which come into effect next year. Hitherto, the awards from the Whitworth Foundation have included senior scholarships open to holders of degrees or higher national certificates or diplomas in engineering; scholarships open to engineering apprentices of at least two years' standing, and prizes awarded to unsuccessful scholarship candidates whose work deserved recognition. Since these awards were instituted, however, there has been a considerable increase in the number of maintenance allowances and scholarships from public funds given to enable suitable students to obtain university degrees or to undertake other forms of full-time further education. The Ministry of Education says that this has had a marked effect on the entry for Whitworth scholarship examinations. At the same time, the need for post-graduate awards has increased, following the advances which have taken place in all branches of technology and an increasing recognition of the value of highly trained technologists in industry. In order to meet these changed conditions, therefore, the Minister of Education, as trustee of the Sir Joseph Whitworth Foundation, has decided to increase the maximum number of senior scholarships from two to three, each of which will have an annual value of £500, which may be supplemented by dependants' allowances. These awards will be available for post-graduate work and will be known as Whitworth fellowships. The award of ordinary Whitworth scholarships is to be discontinued. A number of Whitworth prizes, each valued at £50, will be awarded each year to unsuccessful candidates for fellowships whose work deserves recognition. The leaflet giving full details of the awards is available from H.M. Stationery Office, price 3d.

British Chemical Plant Manufacturers' Association

THE report of the British Chemical Plant Manufacturers' Association for the year 1954 has now been published. It records that membership has continued to increase, the total now being 209. On the subject of home affairs, the report mentions that under conditions of freedom from controls a number of expansion schemes were completed last year, to increase the capacity of the industry, while others were further developed, and goes on to note the increase in collaboration between the chemical and the chemical plant manufacturers. There are notes on the question of standardisation and the recommendation to the British Standards Institution to prepare a standard for sight and light glasses, and a code for the vacuum testing of vessels. Part of the report deals with chemical engineering education and a survey of the available facilities, together with the extent to which they are used. Reference is made to the suspension of the facilities for duty-free imports of machinery and to the resumption of such facilities with reservations, together with the question of their extension to plant. Another section of the report is concerned with overseas trade and notes that the demand for chemical plant continues to be buoyant and that goodwill, lost in recent years through delay in deliveries, has been mainly recovered. A table gives export statistics and shows the trend of the last three years. Among the other subjects mentioned in the report are credit facilities available to British exporters, chemical plant items included among strategic exports, bilateral trade negotiations, commercial intelligence, and training courses for commercial officers, overseas scholarships, and the plans for a chemical and petroleum engineering exhibition in 1958.

Historic Steam Locomotives

A HISTORICAL exhibition tracing the development of the steam locomotive era has been organised by the British Transport Commission and is being opened to-day in the Shareholders' Room at Euston Station. Known as the "Steam Locomotive" exhibition, it is designed to recall the legendary achievements of steam on rails and, at the same time, by complete contrast, it includes models of the electric and diesel-electric locomotives of recent date. By means of relics, models, paintings, photographs and drawings, it traces the development of the era of the steam locomotive by a retrospect of the work and lives of eight of the great British locomotive engineers for which the period was remarkable. These eight men—Robert Stephenson, John Ramsbottom, Edward Fletcher, Patrick Stirling, S. W. Johnson, Dugald Drummond, G. J. Churchward and Sir Nigel Gresley—played leading parts in locomotive design and a review of their work gives a picture of the whole period of locomotive development from the Rainhill trials up to the present day. Among the items of interest are working models of Stephenson's link motion, and another showing the conjugated valve gear which Gresley used on his famous streamlined "A4" "Pacifics," one of which, "Mallard," still holds the world speed record for steam at 126 m.p.h. A silver model of the "A4" "Sir Nigel Gresley," which the L.N.E.R. presented to Sir Nigel, is among the exhibits. The actual wooden pattern for the driving wheels of Stirling's 8ft singles is displayed, and coloured pictures recall the different liveries used by S. W. Johnson, builder of the Midland "compounds." To bring the picture of the steam era right up to date there is a full-scale mock-up of the cab of British Railways standard class "8," 4–6–2 locomotive, No. 71000, "Duke of Gloucester." Visitors can board the footplate and can see through the driver's window a film showing a stretch of main line as seen by the crew. The exhibition will be open to the public daily until October 29th.

Training of Overseas Graduates in F.B.I. Scholarships

By IAN BUCHAN

The author of this article is an Australian who has just concluded, in this country, a course as a Federation of British Industries scholar. He was with the Fairey Aviation Company, Ltd. Here he discusses the conditions in Australia that make the experience of being an overseas scholar here so valuable an education, and he goes on to discuss some details of the scholarship scheme itself.

IN 1816, the first Australian operetta was produced by transported convicts. Only two lines of it are of much value to posterity, and what those convicts said of themselves has some application to the F.B.I. scholars of to-day :—

" True patriots all, for be it understood,
We left our country for our country's good."

It is generally recognised to-day that an engineering graduate from the average university is of little immediate use to an employer, except perhaps in the fields of scientific research. No student can learn at a desk, or even in a college laboratory, the practical applications of his theoretical knowledge. Only by seeing, or preferably by doing, the work under the conditions he will later have to supervise, can he realise the possibilities and limitations of his training, and be able to correlate the fundamentals he has studied in detail with the economic requirements of industry.

Education of all categories must be a compromise between a student's individual needs and an instructing staff's ability to supply individual programmes. College curricula, therefore, err on the side of safety by covering as wide a range of subjects as possible with a concession to specialised requirements in the form of departments covering allied interests, such as civil, geological and mining, mechanical and electrical, chemical and metallurgical, &c. If it is agreed that industry needs technicians trained to degree standard (and there is not complete agreement among industrialists in Australia that such is the case), it should be the right of industry, as the customer purchasing manpower, to have some say through the professional institutions in the courses to be followed. Britain is fortunate in this regard in having technological centres of training strategically placed with respect to branches of industry, with a teaching bias to local requirements, there being a greater emphasis on heavy engineering in the Glasgow and Durham Universities, where the shipbuilding and structural industries are prominent, while mass-production techniques receive more attention in the Birmingham area due to the proximity of the motor-car industry and the manufacturing concentrations of the Midlands. A student at such a centre has excellent opportunities to obtain practical experience either in vacations or between terms of the so-called " sandwich " courses, so that on graduation his qualifications are more attractive to employers in certain industries.

Australian Conditions

Not all countries have the industrial development to support such technological universities, and the students of these countries and indeed, the countries themselves, are placed at a disadvantage relative to those more highly developed. The usual law of supply and demand cannot, in these days of rapid scientific development, be expected to solve the problem by turning out qualified men as required. Development follows scientific enquiry and application, and capable men are needed to instigate and lead in this development. Tuition to a high theoretical standard can fairly easily be given by universities using a relatively small staff, but where industry cannot provide an equally high standard of practical training, the student must be prepared to leave his own country to gain that experience. In any scheme, therefore, which seeks to provide graduate training, the industrial background of the graduate's country of origin must be taken into consideration.

The greater part of the social progress of the world has taken place in the last 150 years. Certain it is that more progress has been made in that period than in the preceding 1800 years of the Christian era, and that most of the credit, or otherwise, can be given to the technological and scientific advancements of the nineteenth and twentieth centuries. It must be remembered that while the Industrial Revolution was taking place in Britain, Australia was striving to eradicate its birth stain and become recognised as a country worthy of development. While Britons were growing up with the inventions of the nineteenth century, Australians were still struggling to obtain the necessities of life from the newly-explored areas of their continent, and in general had no time or thought to spare for the scientific developments going on overseas.

Technological education in Britain seems to have had a beginning with the establishment of the Glasgow Mechanics Institute in 1804, the year in which the penal settlement at Port Arthur in Tasmania was opened. No figures are available for comparison, but it is probable that attendances at the latter were more heartening to the warden ! The first steam engine was erected in Sydney in 1815, the year of Waterloo, and when Birkbeck founded his Mechanics Institute (now Birkbeck College) in 1823, a pardoned convict named Lennox was completing the oldest bridge on the Australian mainland. The government of this country made its first grant to an evening college in 1857, two years before Burke and Wills died of exposure and starvation in making the first traverse of Australia from south to north, and there was still not a mile of railway line in operation in the country at that time. Convict transportation to Western Australia ceased only a few years before Otto's experiments which led to the development of the internal combustion engine.

It must not be thought that those years represented the dark ages of Australia's engineering history. Among other things, sugar refining, iron smelting, weaving, coalmining and food-stuff manufacture on a small scale were all begun in the first half of the nineteenth century. But they were begun mainly because of the isolation of the colony. Furthermore, the men with the technical knowledge to carry out those processes were all immigrants, forced or voluntary.

In 1851, the gold discoveries in New South Wales and Victoria, besides causing a depletion of male labour in what industries there were, produced an unprecedented flood of immigrants, the population doubling itself from 400,000 in 1850 to 800,000 in 1855, and the 1,000,000 mark was reached by 1858. In the recession which followed the drop in the price of gold in 1855, this surplus of labour, much of it skilled, was made available for industrial and agricultural development, which now lagged far behind the demands of the population. That gap has never yet been overcome and with an immigration since the war of a quarter of a million people per year, the race to close it is developing in intensity. Detailed figures of the years preceding Commonwealth federation in 1901 are not available, but it is clear that the main need for engineers was in the coal mining and road and railway construction fields, as the existence of high inter-colonial (i.e. inter-state) tariffs coupled with the still low population density, made most manufacturing an uneconomic proposition. What technical education there was for those born in the new land was by word of mouth from the experienced immigrant, but the struggle to put it on an organised basis took many more years.

In 1850, the first university was founded at Sydney, followed by Melbourne 1853, Adelaide 1874, Tasmania 1889 (the year the population reached 3,000,000), then Queensland in 1909 and Western Australia, still the only free university, in 1911. The first chairs were in classics, mathematics, chemistry and experimental philosophy, and it was Ballarat in Victoria which led in technical education with its School of Mines, opened in 1870. In 1880 the Faculty of Experimental Philosophy at Sydney was expanded to cover physics, geology and mineralogy, and in 1882 a lectureship in engineering was founded which blossomed to a professorship two years later. Evening school education started officially in 1883, though no students enrolled for a further nine years. The first graduate in engineering from Melbourne University was a civil engineer in 1883, and it is an indication of the demand to realise that there was a gap of a quarter of a century before the first degree in mechanical engineering in 1909, then electrical engineering in 1915, metallurgy in 1925 and chemical engineering in 1953.

In 1896 the Governments of New South Wales and Victoria agreed that a factory was " an establishment of four or more people making for trade, wholesale, retail or export." A grant to Sydney University by Sir Peter Nicol Russell of £100,000 for a chair in mechanical engineering in the ensuing eight years gave that branch of industry an impetus which is not yet spent. The following table shows the increase in the number of factories conforming to the above definition, from 1901 to 1950, and by comparing the personnel table with the current population it can be seen that the proportion of the population engaged in manufacturing has risen from 5 per cent in 1901 to 11·6 per cent in 1950.

Year	No. of factories	No. of employees (N1)	National population (N2)	N1/N2 per cent
1901	11,143	197,783	3,825,000	5·2
1911	14,500	312,000	4,574,000	6·8
1921	18,000	379,000	5,511,000	6·9
1931	21,700	337,000	6,553,000	5·1
1941	27,000	725,000	7,144,000	10·15
1950	43,100	969,000	8,316,000	11·65

That educational progress has been slower can be gauged from the following figures of expenditure on technological education in 1937–38 in three countries :—

U.S.A. £97,000,000 ... Great Britain £6,500,000 ... Australia £400,000

Even allowing for the large variation in

populations, Australia's contribution was pitifully small, but by 1949 it had exceeded £4,000,000. Tuition has been along two distinct lines, the universities supplying a full-time three or four-year course as in British universities, leading to a degree, and technical colleges providing a part-time course of up to five years (of four or five nights per week) leading to a diploma. The standards are generally equal, but it is claimed that, even though the university students are encouraged to obtain practical experience during vacations, and must pursue an approved practical training of six months before embarking on the final year, the part-time student is of more use immediately on completion of his course than a full-time university man at graduation. Two points make this an unfair comparison, the effect on one's health of long hours of study on top of a full day's work, and the fact that the diplomate has usually been in a job and familiar with its requirements for a long period when the comparison is made.

Lecturers to both sets of students unhesitatingly recommend an overseas acquisition of practical experience, which due to the relative infancy of many spheres of industry is as difficult to obtain in Australia as in many other newly developing countries. It is unfortunate that not a few leading Australian engineers have for many years opposed this view, retarding progress still further.

Overseas training has long been available to graduates and diplomats with little or no practical experience, through the graduate apprenticeship schemes of some of the larger industrial undertakings of this country. Under these schemes young engineers are assisted to work their way to this country, usually classed as sixth engineer on a ship which only carries five, at a shilling a month, and are included in the graduate-apprentice training schemes of those companies for two years. The benefit to industry as a whole, due to the generosity of such firms in providing training, has often been acknowledged, especially by smaller establishments, who though unable financially to carry out such a comprehensive training, often profit directly by the subsequent acquisition of one of these trainees to their own staffs, but there are, as can be seen, severe limitations to the training available.

To a country with long lines of communication and vast areas of land of small unit productive area, but still largely unknown geologically, there has been no access to graduate training in civil, agricultural or mining engineering during the years when those branches have been most in demand. Specialised knowledge, which is available to the mechanical and electrical fields at graduate apprentice level, has had to be gained at greater expense by sending more senior officers overseas, or by substantial additions to an already well-filled university or technical college programme. A graduate-apprenticeship of the kind mentioned above is an individual contract between a student and a company, and the student is selected with a fairly obvious eye to his future value to that company and its products. The net result has been that though some of the graduates do return to their own countries to the benefit of industry there, a large proportion find greater opportunities in this country and stay on at the end of their two-year contracts, their experience being lost to Australia, perhaps for ever, but certainly at a period in their lives when their enthusiasm for what they have learnt is at its peak.

* * *

In 1952 applications were first invited in Australia for Federation of British Industries Overseas Scholarships, and from the first it was evident that the objects of these scholarships overcame many of the deficiencies of the graduate apprentice-training schemes. The whole of the vast resources of British industry, covering many fields such as civil, mass production, municipal and aeronautical engineering, previously closed to overseas graduates, were now being made available. It is obligatory for the student to return to his own country and to the practice of his profession within six months of completing his training. Due to the emphasis on a long-term export policy, the F.B.I. scholarships aimed at a comprehensive survey of the branches of interest rather than a few specialised phases, on the assumption that it is less important to carry information in one's head than to know where to seek it.

The cost of transport to and from the United Kingdom, and a reasonable living allowance for a single man while in this country, were to be paid by Australian Government, U.K. Government and F.B.I. contributions, and the F.B.I. arranged with the firms willing to accept trainees to provide a suitable programme of training. A list of seventeen firms willing to have an unknown Australian turned loose upon their organisations was supplied to each applicant, who was invited to nominate two in the order of his preference. This list provided an excellent cross-section of industry, ranging from tool and gauge manufacturers and aircraft constructors to consulting civil engineers and those engaged in power station and municipal equipment manufacture. Selection of scholars was made initially by a committee of engineers and representatives of Commonwealth universities and Government Departments concerned with education and industry. Recommendations were forwarded to London and final selection was made by the F.B.I. scholarships committee.

The eleven scholars selected came from all branches of Australian engineering, from firms engaged in mass production techniques, national industries of power generation and water supply, design offices and heavy construction work. Graduates and diplomates were included ; several were married men, some with families. Their ages ranged from twenty-one to twenty-nine years and industrial experience varied from one to eight years after graduation. Thus, all of the group had had some experience in responsible engineering positions, and a few had already undergone courses of practical training with firms in Australia. It may be said that they formed eleven individual problems for Mr. W. V. Jenkins, the manager of the F.B.I. scholarship scheme, but the policy of leaving the detailed planning of programmes to the firms, and the responsibility for getting the most out of the programme to the student himself, has in the main been most successful.

It soon became apparent that students attached to smaller firms with no existing graduate-apprenticeship schemes, were generally better off than those in larger establishments with long-established schemes. Students allotted to existing schemes soon lost their identities as F.B.I. scholars, and a problem perhaps peculiar to overseas students arose. In any training scheme with a large turnover of graduates out to get basic practical training of a general nature, it is impossible to allocate them to responsible jobs within the normal flow of factory work. Thus the emphasis is on learning by observation, instead of by participation as is done with more facility in Australia, where the labour demand still exceeds the supply. There is a sense of urgency in the case of the overseas graduate, who sees this as his only opportunity to visit this country and all his learning must be acquired in this one visit, whereas a British graduate, being on the spot, can refresh his memory fairly easily in later years. Foreign and Commonwealth students, particularly as they have had some practical experience and held positions carrying responsibility in their own countries, find the production line technique of graduate apprentice schemes frustrating and boring. This problem is too general among them to be classed as conceit. Once it was realised and recognised, frank discussion with education supervisors took place and remedies were applied, which in some cases by agreement with the Federation meant transferring to another firm or to one of the national industries for more advanced training and operational experience.

This has been a big step forward, as one of the prime objects of the F.B.I. scheme is to arm scholars with a comprehensive knowledge of what British industry is capable of doing, and to help them to make personal contacts which will enable them to make use of and enlarge that knowledge in later years to the benefit of international prosperity. Students attached to smaller firms which had no established form of training at graduate level, found in the main that they were able to discuss programmes with senior members of the firm, during which discussion the student's academic and practical knowledge was revealed. In the light of his interests and aims, a mutually satisfactory schedule could be drawn up. It is easier to follow a student's behaviour and progress in a smaller firm, and he finds it easier to cover the whole of the firm's activities, thus allowing him to come to an earlier decision on specialised investigation. A student who is conscientiously trying to make the most of his time, must feel he is being of more use in a small organisation than just being another component in an education production programme.

Engineers in rapidly developing countries tend to reach positions of responsibility at an earlier age than their contemporaries in Britain. Most F.B.I. scholars to date have been in positions of responsibility even within a short interval after graduation, and to come away for a period of two years means, for most, a considerable financial sacrifice. It is important to them that theirs is not a wasted period, that a large part of the time is not taken up with duplicating work they have already done in their homelands unless they can gain from the comparison in methods or conditions. Their attitude to training is likely, in view of their backgrounds, to be more serious than those of similar ages in this country, many of whom use a graduate apprenticeship more as an extension to academia than as an introduction to industry.

In the short time that has elapsed since the scholarships were inaugurated, additions and alterations have been made to overcome some of the difficulties mentioned in the preceding text. The scholarships are now divided into three categories, and that which has been the one under discussion up till now is type A, i.e. training is for a two-year period with a living allowance of £390 per annum, plus travel to and from the United Kingdom. Type B is similar in all respects to type A, except that it requires a deposit from the scholar of £200 towards his maintenance, plus his return fare from the U.K. He bears the cost of his travel to this country, and is paid the same living expenses as type A students. Type C is designed for more senior engineers whose employers are willing to release them for a six or twelve-month

period, to gain knowledge of some particular field or process. The scholar or his employers pay his travel costs and contribute at the rate of £100 per year towards his maintenance.

This subdivision which has been made seems to be ideal, but requires more co-operation from industry in the scholar's homeland. Types A and B scholarships are admirably suited to the needs of single graduates with limited experience in their own countries, while the shorter type C category holds more attraction for the more experienced man, who neither needs nor can spare the two years in order to gain some particular facet of engineering knowledge which will greatly benefit his career, and perhaps his country. At present it appears that Australian industry will require much more canvassing than the British to make the type C scholarships a success.

There are further advantages in training of this kind which cannot be measured in terms of money or facts and figures. Two years, particularly for a young and impressionable graduate, spent in a country where customs and climate differ so much from his own, must have lasting effects on his outlook, when that period, which seemed an eternity in prospect and has become nothing in retrospect, recedes into a more distant, but ever-cherished memory. He must have learnt to make good use of his time, and human nature being what it is, he has probably spent more of his leisure hours in seeing the country and meeting its people than in reading engineering journals. Opportunities are plentiful through the F.B.I. and the British Council for mixing with people of all classes, and it is a special virtue of the F.B.I. scholarships that such is the independence and initiative required of the scholar that what he assimilates is in direct proportion to his ability to get along with those he meets. The general broadening of mind and the personal contacts made will in the long run count for more than any manual dexterity developed in the machine shops of this country.

As one of the original Australian scholars, I only voice the opinions of them all by saying that the F.B.I. scholarships have been a courageous and successful venture. No one knows better than ourselves that whether we have learnt anything will not be proved until we have proved ourselves. The F.B.I. scholarships are dependent like any other venture on the end-products—us.

Pitch Errors of the Serrations of Gas Turbine Blades*

By L. W. NICKOLS†, B.Sc, (Eng.), M.I.Mech.E., A.M.I.Prod.E.

The tolerances on the spacing or pitch of the serrations on the fir-tree roots of gas turbine blades are very small, amounting to only a few ten-thousandths of an inch. In order to verify that the pitch errors are within these tolerances an accuracy of measurement of the order of ±0·00005in (±1·25μ) is desirable, and at the same time a high speed of measurement is required in order to cope with large numbers of turbine blades. To satisfy these two main requirements a new comparator‡, described below, has recently been designed and constructed at the National Physical Laboratory. This comparator measures the pitch of the pressure-flanks of the serrations, that is the flanks that take the load under operating conditions, but it may be easily adapted to measure the pitch of the centres of the grooves.

Principle of Operation

THE turbine blade is mounted in the workholder of the comparator at such an angle that the pressure-flanks of all the serrations on one side of the root lie in horizontal planes; this arrangement is shown diagrammatically in Fig. 1. The pitch of these pressure-flanks is then obtained by measuring their vertical heights above the pressure-flank of the lowest serration, which is held in contact with a horizontal datum surface on the workholder. These measurements are made by means of the turret shown in Figs. 2 and 3, which rotates about a vertical axis and carries a number of styluses arranged radially around its periphery. Each stylus is mounted on a spring-strip suspension so that it is free to move in a vertical direction. As the turret is rotated each stylus in turn engages with the serration it is intended to measure and, through the medium of an adjustable strut, registers its vertical height on a single comparator head placed directly above the serrations. Adjustments are provided to enable the instrument to be set correctly with the aid of a simple setting fixture, and the comparator head then records directly the errors of pitch of the pressure-flanks with reference to the lowest pressure-flank.

In one revolution of the turret the errors of pitch of all the serrations on one side of the turbine blade root are measured. The pitch errors of the serrations on the other side of the root are measured after reversing the blade in the workholder. The turret is rotated by an electric motor, and suitably mounted cams which operate a microswitch enable the speed of rotation to be reduced at the measuring positions to facilitate reading the comparator head. The addition of further workholders and comparator heads arranged radially around the turret is possible by slightly modifying the design, thus permitting a number of turbine blades to be inspected simultaneously.

The various parts of the instrument are described in more detail in the following paragraphs.

The Workholder

The turbine blade is mounted in a clamp (Figs. 2 and 4) consisting of two collinear fixed anvils (*A*) which engage with the lowest serration on one side of the blade, and a spring-loaded anvil (*B*), placed centrally between the other two anvils, which engages with the corresponding serration on the other side of the blade. When the blade is clamped in position both flanks of each of the anvils are in contact with the flanks of these serrations, and there is a clearance between the crest of each anvil and the radiused root of the serration. In the measuring position the pressure-flank of the lowest serration on one side of the root of the blade is held against the horizontal datum surface (Fig. 1) of the workholder, which is itself parallel to the base of the workholder and normal to the axis of pitch measurement.

The workholder may be moved along a dovetail slide on the base-plate of the comparator in a direction tangential to the circles swept out by the measuring styluses, thus permitting the uniformity of pitch along the lengths of the serrations to be explored. The workholder is clamped at any position along the length of this slide by means of a gib strip and clamping screw.

The Turret

The turret (Fig. 2) rotates on plain bearings about a vertical column (*C*) mounted on the base-plate and its weight is taken by a ball bearing.

The body of the turret (Fig. 3) has symmetrically disposed flats machined on its periphery, the number of flats being one less than the number of serrations on one side of the turbine blade root. Each flat carries a strut assembly (*D*) (Fig. 4) mounted on two similar pairs of spring-steel strips (*E*); each pair is in the form of a vee, one being attached to the upper part and the other to the lower part of the strut assembly. This form of suspension utilising two parallel vees provides freedom of movement in a vertical direction with excellent lateral rigidity.

Each strut assembly comprises a lower block (*F*) (Fig. 2) which is connected to an upper block assembly (*G*) by means of a strut (*H*), the length of which is adjustable. The lower block carries the measuring stylus and the upper block assembly operates the comparator head by means of the ball (*J*). The strut is constructed of two parallel spring-steel strips connected together rigidly at the ends. Each of the two strips has a central plate attached by means of Araldite. By pulling the two central plates towards each other by means of the central adjusting bolt (*K*), the overall length of the strut is reduced. This type of strut[1] has the advantage that it may be designed to provide a high sensitiveness of adjustment of the overall length in combination with a large range of setting. The particular strut employed on this comparator has a sensitiveness of adjustment of 0·00001in (0·25μ) combined with a range of length adjustment of about 0·005in (125μ). In addition to this fine adjustment, a rough adjustment of the overall length of the strut assembly is provided by means of the slotted hole (*L*) in the upper block assembly.

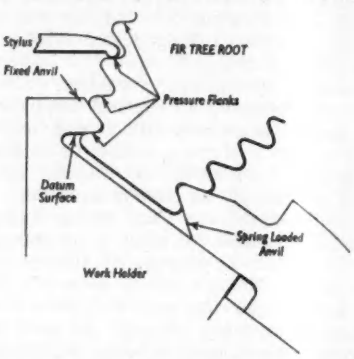


Fig. 1—Fir tree root held in workholder

The overall lengths of the strut assemblies are nominally the same but each stylus is at a different height from the base of the lower block, according to the serration it is intended to measure. The projection of each stylus beyond the vertical face of the lower block may be adjusted by the grub screw (*M*).

An end-stop (*N*) with a screw adjustment, is provided for each strut assembly. Each end-stop is set so that when the stylus is disengaged from the serration on the blade the stylus is a few thousandths of an inch below its measuring position. When the stylus is moved around to enter the serration the radius on the stylus provides a "lead-in" so that it engages without shock. The end-stops are mounted on a large diameter pulley (*O*) which is fixed to the base of the turret. The latter is rotated by an electric motor which drives a belt engaging with a vee groove on the periphery of the pulley. On the upper surface of the pulley cams are arranged mid-way between the end-stops. These cams operate a microswitch, mounted on the base-plate of the comparator, which switches an extra resistance into the motor circuit just before each stylus engages its serration, thus slowing down the turret to assist the stylus to engage without shock and to facilitate reading the comparator head.

An arrangement for adjusting the measuring force on each stylus is provided in the form of a leaf spring (*P*) which bears on a ball attached to the underside of the upper block. This leaf spring is attached rigidly to a lever which pivots on the body of the turret so that when the set

* Communication from the National Physical Laboratory.
† Principal Scientific Officer, Metrology Division, National Physical Laboratory.
‡ Patent applied for.

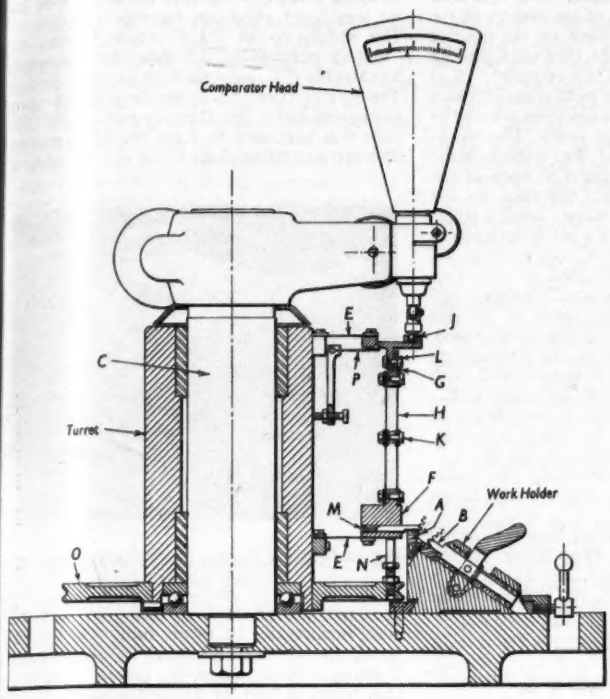


Fig. 2—Comparator showing one strut assembly at measuring position

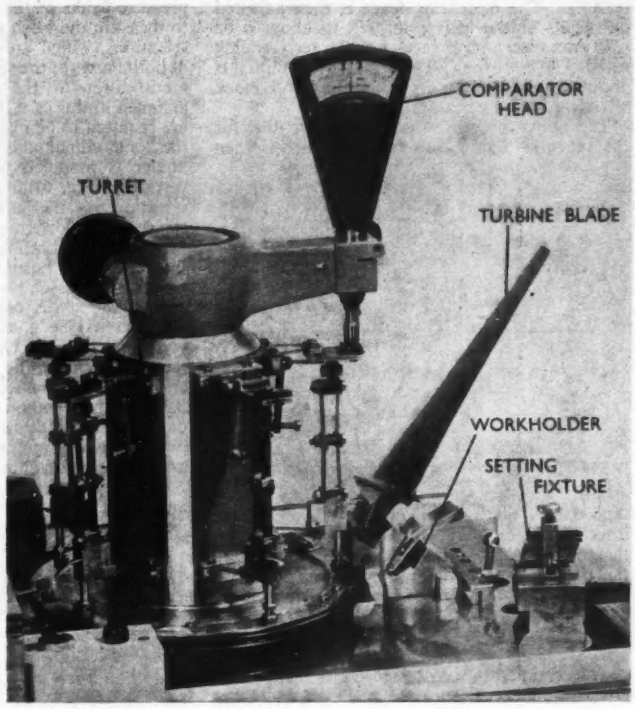


Fig. 3—Comparator showing turret with strut assemblies and setting fixture

screw at the end of the lever is suitably adjusted an upward force is applied to the strut assembly.

Measuring Styluses

The upper part of each stylus is cut away so that it clears the flank opposite the pressure-flank of the serration. The contact face is approximately spherical in shape to provide a lead-in to the serration as the turret is rotated and to localise contact to the mid-point of the pressure-flank. The stylus is normally of hardened steel but may be faced with a wear resistant material such as tungsten carbide.

Comparator Head

A sensitive comparator head is mounted, with its measuring axis vertical, in a split clamp on an arm attached rigidly to the central column (*C*) (Fig. 2). The clamp permits vertical adjustment of the comparator head. The comparator anvil has a spherical contact surface of large radius and, to reduce wear, is faced with tungsten carbide.

Setting Fixture

The base of the setting fixture (Fig. 5) has its upper and lower faces finished accurately flat and parallel. On top of the base are clamped a number of setting pieces, each having accurately flat and parallel upper and lower faces and of a thickness equal to the basic pitch, measured normal to the pressure-flanks, of the serrations on the turbine blade. Between the upper face of the base and the lowermost setting piece are interposed slip gauges so that the height of the uppermost slip gauge above the lower face of the base is equal to that of the datum surface above the base of the workholder (Figs. 1 and 5). The setting pieces have their leading edges relieved and are staggered by the same amount as the corresponding serrations of a turbine blade held in the workholder. When the setting fixture is placed on the base-plate of the comparator the upper surfaces of the setting pieces are at the same heights above the base-plate as the pressure-flanks of a perfect turbine blade root held in the workholder.

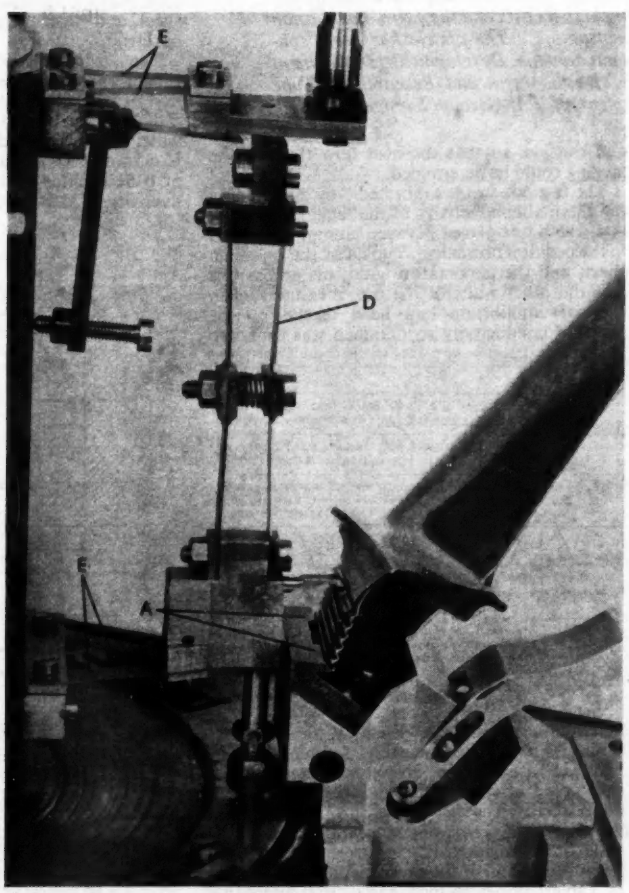


Fig. 4—Strut assembly and spring-strip suspension

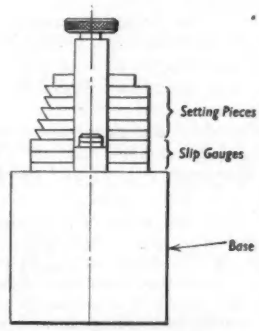


Fig. 5—Setting fixture

Setting and Operating the Comparator

The workholder is removed from its slide on the base-plate and is replaced by the setting fixture. The turret is rotated until the lowermost stylus is in the measuring position, in contact with the appropriate gauging face of the fixture and directly under the comparator head. By means of the slotted hole (*L*) (Fig. 2) in the upper block assembly (*G*) the length of the strut assembly is adjusted until a reading is obtained on the comparator head. The fine adjustment (*K*) of the strut is then used to produce a zero

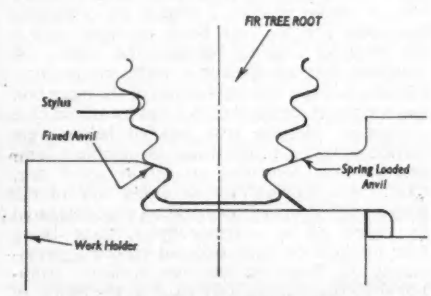


Fig. 6—Fir tree root held vertically in work holder

reading. The measuring force is then adjusted by means of the leaf spring (*P*) to about 8 oz (225 grammes) and, if necessary, the zero reading reset. The end-stop (*N*) is then adjusted until it is about 0·002in (0·05mm) below the lower block (*F*) in the gauging position.

The above procedure is repeated in turn for the other styluses. The setting fixture is then

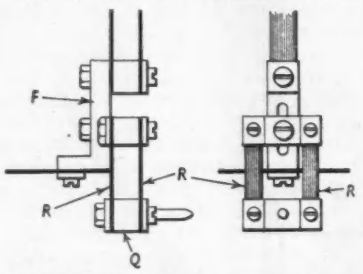


Fig. 7—Modification to lower part of strut assembly to enable the pitch of the centres of the serrations to be measured

replaced by the workholder and a turbine blade inserted in the latter. The readings obtained on the comparator head as the turret is rotated are the errors of spacing of the pressure-flanks with reference to the lowest pressure-flank as a datum.

Modifications

The comparator described above has been constructed to measure the pitch errors of the pressure-flanks of the serrations. If it is desired to measure the pitch errors of the centres of the serrations, which are dependent on the spacing of both flanks of the serrations, then the following modifications to the design are required. It is assumed in this case that the pitch measurements are required to be made in a direction parallel to the longitudinal axis of the root. The workholder is modified to hold the turbine blade vertically (Fig. 6) and the pitch of each of the serrations is measured with reference to the centre of the lowermost serration, using a stylus which contacts both flanks of a serration when in the measuring position. The lower block (*F*) of the strut assembly is modified as shown in Fig. 7, the stylus being mounted in block (*Q*) attached to the ends of two pairs of parallel vertical leaf springs (*R*). As the turret is rotated, the stylus enters the serration being measured and the leaf springs keep it in contact with both flanks of the serration. The setting standard may be a turbine blade root having known errors of pitch, and allowance can be made for these errors when adjusting the lengths of the struts.

The author desires to acknowledge the assistance rendered by Mr. J. E. Furse in the design and experimental work.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

Reference

[1] "An Adjustable Strut for Use in Measuring Instruments," Nickols, L. W., *Journal Sci. Instrum.*, 1955, 32, 149.

Economics of Aluminium Sheet as Cladding for Industrial Buildings

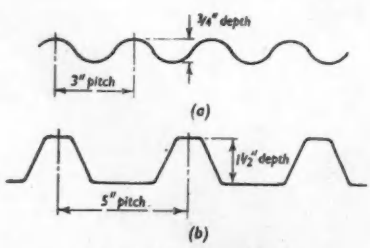
The thermal transmittance of corrugated aluminium sheeting has been the subject of a programme of laboratory tests, which are described, and the results have been considered upon an economic basis. The findings have been applied to an actual building and a figure established for the saving in fuel costs and the extra installation costs compared with a basic system of construction. The article has been contributed by, and the research work carried out by, the Development Department of T.I. Aluminium, Ltd., the Department of Development and Research of Tube Investments, Ltd., and the Fuel Department of T.I. (Group Services), Ltd.

THE attractive properties of aluminium building sheet—its good durability, pleasant appearance, high strength to weight ratio, and its ability to withstand accidental damage—are becoming well known as is shown by its increasing use on industrial buildings such as illustrated. Lately a great deal of attention has been directed towards another important property—its very low thermal transmittance value. With the rising cost of fuel, coupled with the desire to improve working conditions, any saving in fuel costs which can be achieved with a moderate capital outlay are worthy of attention. With a view to obtaining more data on this subject, a programme of testing work has been carried out to determine the thermal transmittance (" U ") values for the two kinds of aluminium building sheet now in common usage (Fig. 1), both individually and in conjunction with various lining materials. The results of this work are given in Table I.

Testing Procedure

The sheet or combination of sheets under test formed the top of a rectangular double-walled box, as shown in Figs. 2 and 3, the remaining four sides and the base being insulated with a 4in layer of lagging between the walls. A resistance mat was fixed in a horizontal position midway between top and bottom of the inner box and the power supplied to this was measured by a wattmeter. All the tests detailed below were carried out in a room where the ambient temperature was controlled to within ±0·5 deg. Cent. Air temperatures on either side of the specimen sheet under investigation were measured by copper-eureka thermocouples, there being four of these on each side, all spaced approximately 3in from the specimen surface. Additional thermocouples were fixed to the centre of each side of the test box and the base, both inside and outside, so that the heat flow through the lagging could be determined.

The test box was " calibrated " by determining the thermal conductivity of the lagging material. A 4in slab was placed between aluminium panels in the position normally occupied by the specimen sheet, and the temperature gradients across this and the other walls of the box measured when thermal equilibrium had been reached ; the value of conductivity so obtained was found to



(*a*) General-purpose corrugated sheet.
(*b*) Industrial corrugated sheet.

Fig. 1—Forms of corrugated sheet

agree closely with that given by the manufacturers. For tests on sheeting, samples 32in by 32in were used and the air temperature on either side noted after thermal equilibrium had been established. The heat flow through the sheet was determined by difference, and the " U " value finally calculated.

Consideration of the experimental results given in Table I brings to light one or two interesting facts. The values obtained for 20 S.W.G. and 22 S.W.G. sheeting of both kinds of aluminium building sheet confirm that metal thickness has no significant effect on thermal transmittance. The difference in " U " value between the " general purpose " and " industrial " sheeting is explainable by the difference in their profiles. The former sheet has a profile which is nearly sinusoidal and a flat sheet approximately 35in wide was necessary to form the 32in specimen. The corresponding sheet width for the industrial

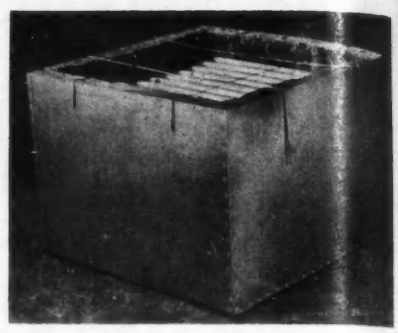
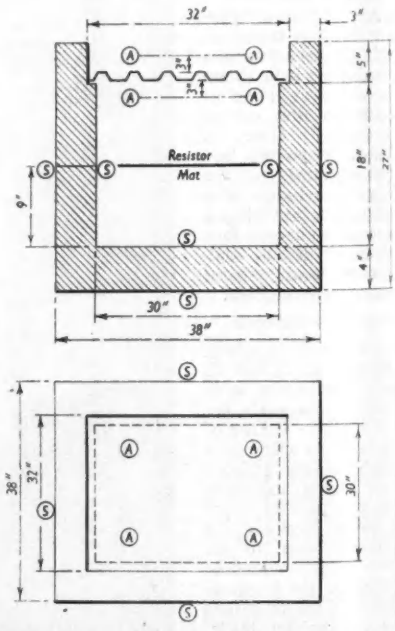


Fig. 2—Double-walled box used for determining " U " values

specimen was about 42in, giving an increase in total surface area of 18 per cent. On the other hand, the corrugation depth of the industrial sheeting is twice that of the general purpose, so that some, at least, of this additional area is less favourably disposed for heat loss. Bearing this in mind, the measured increase in " U " value of only 12 per cent for 20 S.W.G. industrial sheeting seems a reasonable figure.

The use of insulation board liners gives a substantial reduction in thermal transmittance and eliminates almost entirely the effect of sheet profile. A further slight reduction in " U " value is effected by having an air space between roofing sheet and liner (corresponding to an installation where the liner is fastened under the roof purlins) instead of having the corrugated sheet and liner adjacent (liner fastened over purlins).

The Institution of Heating and Ventilating Engineers has published tables in its publication *Computation of Heat Requirements for Buildings*, enabling the change in " U " value when a lining board is fitted to be estimated. If a roofing sheet having an initial " U " value of 0·51 is fitted with an adjacent liner of conductivity 0·35 B.Th.U. per square foot per hour



Positions of eight air thermocouples denoted by *A*, position of ten surface thermocouples denoted by *S*.

Fig. 3—Arrangement of thermocouples and heater in the test box for determining " U " values

per deg. Fah. per inch (a good average value for the sheets actually used), the resulting "U" value is found from the tables to be 0·29. If there is an air space between roofing sheet and liner, this value is found to be reduced to 0·23. The corresponding experimental results given in Table I are 0·25 and 0·22.

Using a liner of 26 S.W.G. corrugated aluminium with intervening 3in air space gives "U" values close to those obtained when an insulation board liner is fitted in contact with the roofing sheet, but higher than those for board liners with a 3in air space. As before, the profile of the roofing sheet has negligible effect on the transmittance of the combination. The use of a coating of aluminium paint gives an increase in "U" value of 20–25 per cent if only one surface is so treated; if both surfaces are painted, the increase will be about 45 per cent. A sample of 20 S.W.G. general purpose corrugated sheet which had been exposed to the atmosphere on a farm building near Warwick for approximately five years was also tested. The surface of the sheet (Fig. 4) showed a typical oxidation, and the "U" value was found to be 0·65. It is not expected that further deterioration of any consequence would take place.

It will be observed from the table of thermal transmittance values that the heat loss through an unlined roof of 22 S.W.G. general purpose corrugated aluminium is less than half of that through an unlined roof of asbestos cement. In practice this would mean a considerable saving in fuel costs as the following example demonstrates.

Example.—Consider a single-storey factory building 60ft span by 200ft long by 14ft to eaves, with a pitched roof 26ft to ridge. The walls are of 9in brickwork unplastered and there are sixteen windows, each 32 square feet in area, down each long side. The ridge of the building runs north/south and there is a steel sliding door size 18ft by 12ft high in the south gable end. The floor is of concrete on hardcore and earth, and there is a continuous run of patent glazing in each roof slope, the total area of roof glazing being 3400 square feet. The building is located on a sheltered site in the Midlands. Heating is by a coal-fired boiler and unit heaters. The building is occupied for five-and-a-half days per week, the working week being sixty-six hours. Heating is likely to be used for twenty-six weeks per year, and the average outside temperature

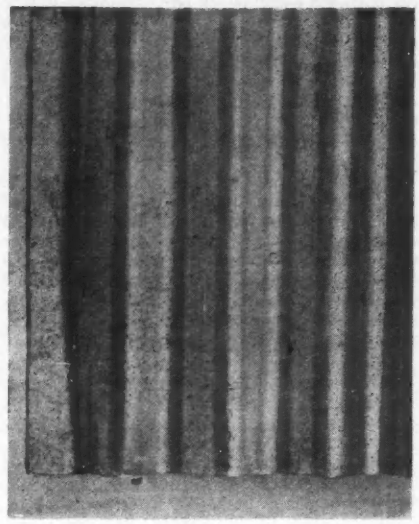


Fig. 4—Sample of general-purpose corrugated sheet showing oxidation after five years' exposure

during the heating season is found, from records, to be 42 deg. Fah. It is desired to maintain a temperature of 65 deg. Fah. in the building; there are two air changes per hour and the boiler preheating period is three hours. The effect of using different kinds of material on the roof (effective area 9600 square feet) are considered and the calculations are shown in Table II.

The following points emerge from the above considerations. (1) The saving in fuel costs after

TABLE I—*Thermal Transmittance Values ("U") for Roofs (Sheltered Conditions)*

Type of main sheeting	Type of lining material	Air space between main sheet and lining	"U" value B.Th.U./ ft²/hour/ deg. Fah.
Experimental results (average):			
G.P. 3in pitch by ¾in corrugated aluminium 20 S.W.G. (0·036in)	None	—	0·51
G.P. 3in pitch by ¾in corrugated aluminium 20 S.W.G. (0·036in)	½in thick proprietary insulating board	Adjacent	0·25
G.P. 3in pitch by ¾in corrugated aluminium 20 S.W.G. (0·036in)	½in thick proprietary insulating board	3in	0·22
G.P. 3in pitch by ¾in corrugated aluminium 20 S.W.G. (0·036in)	26 S.W.G. (0·018in) corrugated aluminium	3in	0·26
G.P. 3in pitch by ¾in corrugated aluminium, 22 S.W.G (0·028in)	None	—	0·52
G.P. 3in pitch by ¾in corrugated aluminium 20 S.W.G. (0·036in). Outside surface coated with aluminium paint	None	—	0·63
G.P. 3in pitch by ¾in corrugated aluminium 20 S.W.G. (0·036in). Inside surface coated with aluminium paint	None	—	0·61
G.P. 3in pitch by ¾in corrugated aluminium 20 S.W.G. (0·036in). Both surfaces coated with aluminium paint	None	—	0·74
G.P. 3in pitch by ¾in corrugated aluminium 20 S.W.G. which had been exposed to atmosphere for approximately 5 years	None	—	0·65
5in pitch by 1½in industrial corrugated aluminium sheet 20 S.W.G. (0·036in) or 22 S.W.G. (0·028in)	None	—	0·57
5in pitch by 1½in industrial corrugated aluminium sheet 20 S.W.G. (0·036in) or 22 S.W.G. (0·028in)	½in thick proprietary insulating board	Adjacent	0·24
5in pitch by 1½in industrial corrugated aluminium sheet 20 S.W.G. (0·036in) or 22 S.W.G. (0·028in)	½in thick proprietary insulating board	3in	0·22
5in pitch by 1½in industrial corrugated aluminium sheet 20 S.W.G. (0·036in) or 22 S.W.G. (0·028in)	26 S.W.G. (0·018in) corrugated aluminium	3in	0·27
Typical figures for other materials for comparison purposes:			
Corrugated asbestos cement	None	—	1·20–1·40
Corrugated asbestos cement	½in thick proprietary insulating board	Adjacent	0·35
Corrugated asbestos cement	½in thick proprietary insulating board	3in	0·31
Corrugated iron ...	None	—	1·25–1·50
Corrugated iron ...	½in thick proprietary insulating board	Adjacent	0·36
Corrugated iron ...	½in thick proprietary insulating board	3in	0·32
Roofing tiles on battens	—	—	1·22
Roofing tiles on boards and felt	—	—	0·33

TABLE II—*Effect of Using Different Materials on Roof of a Typical Single-Storey Factory*

	Roofing material					
	Corrugated asbestos cement unlined	Corrugated asbestos cement with air space and ½in insulating board (fire resistant)	22 S.W.G. G.P. corrugated aluminium sheet unlined		22 S.W.G. G.P. corrugated aluminium sheet with air space and ½in insulating board (fire resistant)	
			In new condition	In oxidised condition	Sheeting in new condition	Sheeting in oxidised condition
Roofing system	1	2	3		4	
Thermal transmittance value for sheltered conditions, B.Th.U. per square foot per hour per deg. Fah.	1·20	0·31	0·52	0·65	0·23	0·25
Heat through 9600 square feet of roofing sheet, B.Th.U. per hour per deg. Fah.	11,520	2,976	4,992	6,240	2,208	2,400
Allowance for height of heated space 12 per cent*	1,382	357	599	749	265	288
Total	12,902	3,333	5,591	6,389	2,473	2,688
Allowance for intermittent heating 30 per cent*	3,871	1,000	1,677	2,097	742	806
Total	16,773	4,333	7,268	9,086	3,215	3,494
Heat through roof sheets for 23 deg. Fah. temperature difference B.Th.U. per hour	385,779	99,659	167,164	208,978	73,945	80,362
Saving in B.Th.U. per hour as compared with corrugated asbestos unlined	—	286,120	218,615	176,801	311,834	305,417
Saving in tons of fuel per heating season of 1,716 hours with coal at 11,500 B.Th.U. per pound heating plant efficiency 60 per cent	—	31·76	24·3	19·63	34·6	33·9
Saving in fuel costs per heating season with fuel at 70s. per ton	—	£111·2	£85·1	£68·7	£121·1	£118·7
Approximate extra initial cost of roofing material, as fixed as compared with cost of asbestos unlined†	—	£588	£264		£852	
Approximate saving in initial cost of heating system‡	—	£450	£275		£500	
Net increase in initial cost	—	£138	Saving of £11		£352	
Number of heating seasons for fuel saving to pay extra initial cost§	—	1·24	0·16	—	2·9	—

* See *The Computation of Heat Requirements for Buildings*, published by the Institution of Heating and Ventilating Engineers. The average height of the heated space is 20ft. The allowance for intermittent heating has been taken as 50 per cent of 60 per cent since the building is of light construction.

† The comparative prices for the different types of roofing material include fixing costs and are those generally obtainable from roofing contractors in the Midlands.

‡ The estimated saving in initial cost of the heating apparatus is based on the following maximum heat requirements for the complete building. See Table III for calculations.
Total heat input required :—

Roofing system 1 : 1,570,940 B.Th.U. per hour
Roofing system 2 : 1,135,540 B.Th.U. per hour
Roofing system 3 : 1,301,895 B.Th.U. per hour
Roofing system 4 : 1,106,175 B.Th.U. per hour

} The cost of the heating installation is based on its having sufficient capacity to give a 35 deg. Fah. temperature rise if required..

§ The number of heating seasons for fuel saving to pay extra initial cost has been calculated on the basis that the aluminium sheets will retain their initial "U" value during the relevant period.

the initial period of capital repayment (less maintenance costs, which for aluminium will be negligible) is clear profit equal to an appreciable capital investment. It will be noted that the initial costs for roofs of asbestos or aluminium, both unlined, is virtually the same when the cost of heating apparatus is taken into account. (2) The relative savings will be greater for buildings which have higher heated spaces, more intermittent heating, and greater sheeted areas. If sheeted sides are substituted for brick walls, as is often necessary in industrial buildings, then the use of aluminium sheet instead of asbestos or steel will show a similar relative saving as for the roof. (No attempt has been made at this stage to study the effect of orientation or wind velocities, but the relative values will be maintained.) If more expensive fuel, such as oil, at 10·5d. per gallon is used, the annual saving in cost of unlined aluminium over unlined asbestos would rise to approximately £140. (3) The advantages of the general purpose aluminium sheet which was used in the example apply equally well to the industrial aluminium sheet. This latter is suited to the larger industrial buildings and caters for British Standard CP.3, Chapter (V): Loadings at purlin centres of up to 7ft. 6in.

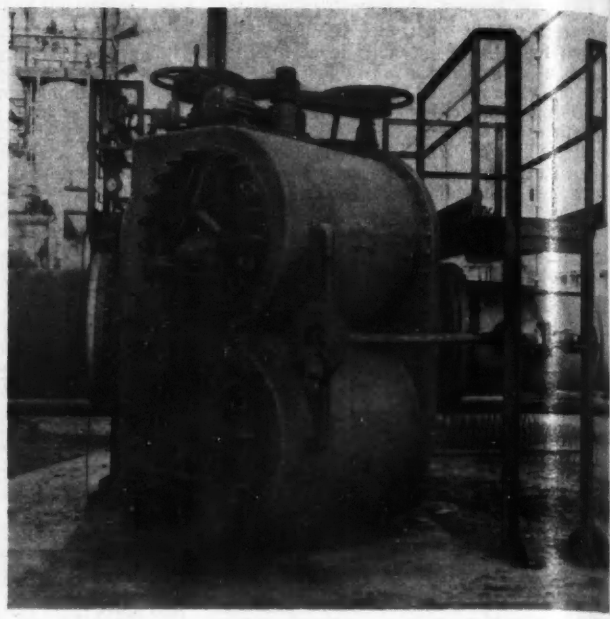
TABLE III—*Heat Loss from Complete Building Less Roof Sheets*

	Area, square feet	"U"	B.Th.U. per hour per deg. Fah.
Structure:			
9ft brick wall ... West ...	2,288	0·42	961
9ft brick wall ... East ...	2,288	0·44	1,007
9in brick gable end North	1,200	0·44	528
9in brick gable end South	984	0·39	384
Side windows ... West ...	512	0·79	405
Side windows ... East ...	512	0·88	451
Door (steel) ... ... South	216	0·79	171
Roof glazing	3,400	1·00	3,400
Floor	12,000	0·2	2,400
Total			9,707
Air changes: 240,000 cubic feet at two air changes per hour ...			9,600
Total			19,307
Allowance for height 12 per cent			2,317
			21,624
Allowance for intermittent heating 30 per cent ...			6,487
Total			28,111

Total heat input per hour for 23 deg. Fah. temperature rise equals 646,553 B.Th.U. plus heat through roof sheeting.
Total heat input per hour for 35 deg. Fah. temperature rise equals 983,885 B.Th.U. plus heat through roof sheeting.

The corrugated aluminium lining sheet used in one of the combinations which were tested has the following properties. The cost is no higher than most fire-resistant lining materials; it cannot become saturated with moisture with consequent staining and sagging; it prevents flame propagation; it has a serviceable finish which can be cleaned and which is suited to industrial conditions; it has excellent light reflecting qualities; it can be fixed with the minimum of accessories and supports; it is available in large pieces up to 20ft long and 3ft wide.

It can be appreciated that there is an economic limit to insulation on a given building depending in the main on the intended end use of the building. In many instances where highly insulated buildings cannot be justified economically, there is a clear need for a cladding with a good inherent thermal transmittance value, which will strike an economic compromise between annual heating costs and initial cost. An unlined aluminium cladding is claimed to meet this need. In the case where a highly insulated building is essential, the foregoing data indicates the suitability of an aluminium cladding combined with an insulated lining.



30in twin strainers fitted in the cooling water system of the catalytic cracker plant at Fawley

Twin Strainers at the Fawley Oil Refinery

THE use of sea water, as the cooling medium, in heat exchangers presents many problems owing to the variable conditions met with in estuarine waters. These problems confronted the Esso Petroleum Company at its Fawley refinery.

In the original layout a coarse screen, fitted at the suction inlet of the pumps to exclude foreign matter, proved inadequate as it was impossible to clean the screen without interrupting the flow of water. In addition, debris passed through partially blocking the heat exchangers, causing them to be shut down with some loss of production and heavy repair costs.

To meet the situation twin strainers, manufactured by Royles, Ltd., were fitted in the suction pipelines, and the sizes supplied covered a range from 8in to 30in bore. The main construction of the units was of high-grade cast iron, with gunmetal facing rings on the valve ports and cages of naval brass with ¼in perforations.

To meet the stipulation of low head loss two 30in fixed-cage "E" strainers, capable of dealing with a flow of 23,500 U.S. gallons per minute, were provided for the catalytic cracker plant, while two 24in "E" units, having a capacity of 16,500 U.S. gallons per minute, were fitted to another of the refinery plants. The static operating pressure was 45 lb per square inch gauge, and the maximum allowable pressure drop through each strainer only 5ft.

Owing to the unprecedented conditions at Fawley, particularly as, once started, the process must continue uninterruptedly for long periods, it was found that the standard design of strainer required modification in order to facilitate cleaning.

In addition it was necessary to guard against the corrosion of the cast iron which was taking place both in the strainers as well as in other parts of the plant. This corrosion attack on the cast iron was met by the application of "Synco" lining to all interior iron surfaces, and consists of a "Neoprene" lining one twenty-fifth of an inch thick, bonded to the metal.

The modifications in the design of the 24in and 30in strainers included a considerably strengthened cage to withstand frequent removal; the provision of a quick-opening cleaning door for normal use, arranged to swing fully clear on a vertical axis, held by a horizontal crossbar and secured by a single capstan hand screw; the enlargement of the piping by which the pressure is balanced on both sides of the valves before the change over is made; and the motorisation of the change-over mechanism. This latter entailed the provision of a flameproof reversible motor and integral reduction gearbox, mounted on top of the strainer and driving each valve spindle through a separate chain. To obviate possible damage to the strainer or burning out of the motor due to overrun, a slipping clutch was fitted between the motor and gearbox. The movement of the valves is controlled by a "push-button" starter, the motor being stopped at the end of their travel by a mercury switch device specially adapted for the purpose. A solid engagement friction clutch was also fitted to enable each valve to be hand operated should the occasion arise. Experience has proved the success of the modifications, the change-over period being reduced to a period of five minutes for one man.

In view of the very frequent cleaning of the cages it was decided to strengthen the removable cages of the type "G" strainers, sizes 8in to 16in, and reduce the time factor in carrying out this operation. A new design was evolved, again employing a single crossbar and capstan hand screw, but having the cover pivoted and fitted with a special design of pressure-retaining ring. Here again the difficulty of handling a relatively heavy cover after the removal of many nuts was reduced to a simple operation taking a matter of minutes.

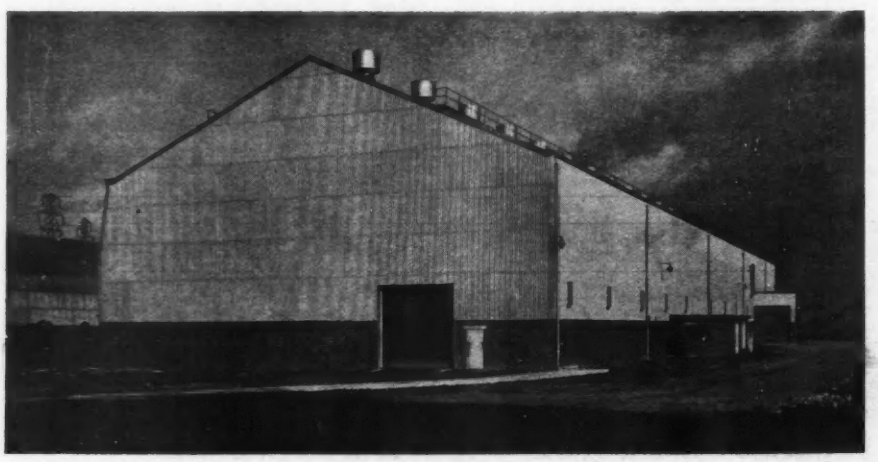


Fig. 5—A typical works building clad with industrial corrugated sheet

Passenger, Train and Car Ferry "Princess of Vancouver"

The Canadian Pacific Railway Company has recently added to its fleet the passenger, train and car ferry "Princess of Vancouver," which has been designed for operating between Vancouver and Nanaimo in the British Columbia Coast Steamship Service. The ship carries 800 passengers, has an overall length of 416ft, a service speed of 15½ knots, and is powered by four sets of pressure-charged diesel engines, each rated at 1575 b.h.p., arranged in pairs, and each pair driving a propeller shaft through reverse reduction gears and individual fluid couplings.

WITH the object of improving the overall efficiency of the ferry service between Vancouver, on the mainland, and Nanaimo on Vancouver Island, plans were developed and designs formulated for the building of a ship which would embody this policy, as advanced by Captain O. J. Williams, of the British Columbia Coast Steamship Service. Linked with maximum efficiency was the need for minimum operational cost, a factor which demanded a high degree of availability and, indeed, the sailing schedule for the ship required the ferry to be on continuous service for 362 days per year, leaving only three days in which to dock the ship for hull cleaning, painting and general examination.

These aims raised difficult maintenance problems, particularly with regard to the propelling machinery, and resulted in the adoption of a multi-engine installation, arranged so that one engine could be shut down and isolated, to permit of overhaul, while the remaining three engines maintained the service speed of the ship. This scheme to carry out maintenance work with the ship in service meant that due regard had to be paid to the weight, size and stowage of engine components to facilitate the carrying out of essential overhauls. Another factor which results in a considerable contribution to the economic running of the ship is the large saving in fuel costs by the installation of the necessary equipment to enable the engines to run on heavy fuel oil.

The order for the ship was placed with Alexander Stephen and Sons, Ltd., of Linthouse, Govan, Glasgow, with Messrs. Milne, Gilmore and German, of Montreal, Canada, acting as consultants, while the main and auxiliary machinery was built by The National Gas and Oil Engine Company, Ltd. Our illustration of the ship on trial shows that T.S.M.V. "Princess of Vancouver" has clean lines, a raked contour plate stem, square stern, two masts and a large, short funnel, all making up a pleasing profile. The launch took place on March 7th and sea trials were carried out on April 20th and 21st on the Skelmorlie mile, when a speed of 16·56 knots was attained at 90 per cent of maximum power and 15 knots was obtained on three engines, the fuel used being Bunker "B," having a viscosity of 1000 seconds Redwood No. 1. On the manœuvring tests the time taken to give astern rotation to the propellers from "full ahead" was twenty-seven seconds.

Electric welding has been largely employed in the construction of the ship and by means of the expanded welding facilities at the builders' yard, it has been possible to fabricate sections of the structure weighing up to 44 tons in the welding bay before transferring to the building berth for incorporating in the main hull. The vessel has been built to Lloyd's Rules for class "100A1 Train Ferry," to Canadian Board of Steamship Inspection approval, and to satisfy the requirements of the British Ministry of Transport for a "Class II" passenger vessel making short international voyages. There are two complete steel decks, namely, the main deck, which is the car deck, and the upper deck. Above this is the boat deck, extending for nearly the full length of the ship, and the bridge deck, with the wheelhouse at the forward end. The hull is transversely framed and scalloped deck beams are used, while longitudinal framing has been adopted for the construction of the double bottom which extends from the bow propeller space to just forward of the aftermost shaft compartments and is arranged for the carriage of water ballast. Those compartments below the engine and generator rooms are arranged to take oil fuel.

Main Particulars

Length overall	416ft
Length on water line	404ft
Length between perpendiculars	388ft
Breadth moulded	63ft
Breadth over fenders	66ft
Depth moulded to main deck	19ft 6in
Draught (load)	14ft 9½in
Draught (light)	10ft 8in
Service speed	15½ knots
Gross tonnage	5500
Passengers	800
Machinery:	
Twin screw, geared drive—four sets of seven cylinder turbo-charged National diesel engines, total power (at 200 propeller revolutions per minute), owners' specification	6300 b.h.p.
Normal output	7000 b.h.p.
Three Brush alternators	450kW
Driven by National F4A8 diesel engines	450 V.a.c.
One Brush alternator (emergency) driven by a National M4AA8 diesel engine	150kW

Below the main deck there are twelve watertight bulkheads to ensure a two-compartment standard of sub-division and to meet the latest requirements of the International Convention for Safety of Life at Sea. All the compartments are provided with 21in diameter escape hatches arranged close to the ship's side on the car deck.

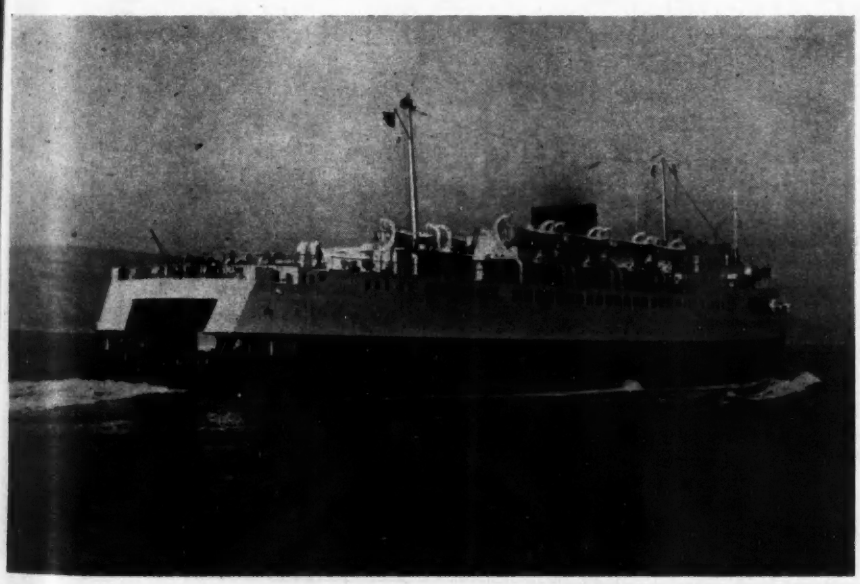
Accommodation and Equipment

Accommodation for the passengers is arranged on the upper and boat decks and takes the form of spacious lounges, there being no cabins provided since it will take only about three hours to make the 41-mile crossing from Vancouver to Nanaimo. In the deck-house, on the boat deck, there are two lounges, one to seat 128 passengers and the other having 116 seats, all of which are arranged in bays at the side of the house. At the aft end of the house is a small cocktail bar which can seat forty-four passengers in tub armchairs, upholstered in red and blue leathercloth, arranged around small plastic-topped tables. At the forward end of the upper deck is a spacious observation lounge which is furnished with tubular, satin-chrome, framed armchairs upholstered in "Dunlopillo" and covered with moquette. Both the sides and curved front of the room are fitted with large metal-framed windows, supplied by Beckett, Laycock and Watkinson, Ltd., and measuring 5ft 3in by 2ft 6in, which are arranged so as to give a clear view to passengers when seated.

From the lounge, frameless glass double doors to port and starboard lead to the spacious main lobby, which has passenger entrances and in which are located the Purser's office, a shop, a first-aid room, and a locker room to take passengers' luggage. Continuing aft the lobby opens on to a lounge with a seating capacity of 324 and further aft again is another lounge, which can be seen in our photograph and which is capable of seating 202 passengers. Both lounges have the seating arranged in bays, in a similar manner to that adopted in the spaces on the boat deck, and all have deep "Dunlopillo" cushions and back-rests covered with material of contrasting colours, which are varied in each lounge. Writing facilities are provided on both decks and, as in the observation lounge, large windows are fitted; these measure 5ft 9in by 3ft and extend for the full length of the lounges, giving the passengers an uninterrupted view.

For the service of light meals there is a coffee shop (illustrated overleaf) which is entered from the lounge on the upper deck and separated from it by a bulkhead fitted with large decorative glass windows. The shop has horseshoe-shaped counters, at which are placed swivel chairs sufficient to seat 115 persons, and the equipment includes an automatic ice maker to produce cubed or crushed ice, soda fountains, milk coolers, salad tables, coffee making units, plate warmers. The steel bulkheads throughout the passenger accommodation are finished smooth with cement and painted in light colours, and the main decoration of the spaces consists of coloured photographs of Canadian scenes in the Rockies, Nova Scotia, Alberta, and British Columbia. Fluorescent strip lighting is fitted throughout. Within the accommodation the decks are covered with an underlay, ¼in thick, of "Aranbee" surfaced with the same thickness of slate or puce marble "Korkoid," supplied by Rowan and Boden, Ltd., while all exposed decks are covered with "Semtex" deck composition, ⅛in thick.

Large cabins panelled in "Avodire" are provided for the captain and chief engineer and the remaining engineer and deck officers have well furnished single-berth cabins panelled in white ash and also a lounge panelled in "Avodire" in the house at the forward end of the boat deck, each cabin having a fixed window with a ventilating top manufactured by Bulls Metal and Marine, Ltd. Most of the crew accommodation is arranged on a flat below the main deck and forward of the generator room. Two-and four-berth cabins are provided and there are separate rest rooms for the engine-room crew, seamen, cooks and



"Princess of Vancouver" on trial on the Clyde

Aft lounge on upper deck as seen when looking forward to port

Looking forward on the starboard side of the Coffee Shop towards one of the horseshoe-shaped counters

stewards, and the deck head is insulated against noise from the car deck. The catering staff have cabins located on mezzanine flats arranged to port and starboard at the aft end of the car deck. The messes for the officers, panelled in Canadian birch, seamen, engine-room crew and stewards are all placed right aft on the upper deck and immediately aft of the galley. The galley, of which we reproduce a general view, is fitted with electric ovens, range, fryers, hot plate and steam ovens, and there are ready-use cold stores, preparing rooms: the equipment was supplied by Russell Food Equipments, Ltd., of Vancouver. A lift at the ship's side links the galley with the provision stores arranged on a flat below the main deck and another lift, also provided by Waygood-Otis, Ltd., is fitted for the convenience of the engineer officers; this lift rises from the engine to the boat deck to give the officers easy access to their accommodation.

The main deck is arranged for the carriage of box cars and other railway rolling stock and road vehicles, and the space, which is two decks in height, extends for the whole length of the ship and can accommodate approximately twenty-eight box cars or 115 motor cars. Our photograph gives an impression of the size of the car deck and the structural arrangements. There are four sets of tracks, consisting of special rails welded to the deck, each equipped with a set of automatic couplers, supplied by the Canadian Car and Foundry Company, Ltd., and fitted to the buffer posts placed at the forward end of the tracks. Westinghouse air brake charging connections are also provided. To allow for the installation of four tracks it was necessary to keep obstructions to a minimum, so casings and stairways are confined to a narrow house on the centre line, while all items of the ship's services are fitted close to the ship's side and inside the line of the web frames. The ship has a square stern, which has been designed specially to allow for the loading of railway rolling stock and road vehicles over the after end of the deck, a recessed sill being provided to take the end of the adjustable shore ramps which form part of the equipment of the new piers at Vancouver and Nanaimo. Road vehicles can be loaded through the side of the ship, and for that purpose there are two sets of large double-hinged doors to port and starboard. There are two rows of Carron's side lights in the ship's side, and two electrically operated large spray-tight steel roller doors, supplied by G. Brady and Co., Ltd., are fitted to close the opening at the aft end of the main deck. The deck covering consists of an underlay of asphalt and aggregate surfaced with ¼in thick layer of non-indent oil and heat-resisting asphalt paving, and to get rid of any excess water rapidly there are a number of automatically opening freeing ports.

Thermotank, Ltd., has been responsible for the ventilation system. Thermostatically controlled filtered and heated air is supplied to the passenger and crew spaces and there is also a system of steam convectors. Galleys, pantries and store rooms, &c., are supplied mechanically with air at atmospheric temperature and exhausted by the same means, while ventilation of the car deck is effected by ten large torpedo fans.

Throughout the ship there are extensive systems of fire protection and detection, and "A" class decks and bulkheads are fitted to conform with the requirements of the Canadian Board of Steamship Inspection and the regulations of the British Ministry of Transport. The ship is divided into zones incorporating fire-resisting doors, manufactured by Roneo, Ltd., and there is "Marinite" fire-resisting bulkheading and also a Grinnell sprinkler system, complete with sprinkler tank, air compressor and twin-ram pump provided by Mather and Platt, Ltd. To limit the effect of a fire on the car deck the underside of the upper deck is completely covered with "Caposite" 1in thick, and as a further safeguard water spray curtains are fitted at three positions. As part of the sub-division arrangements there are seven Donkin power-operated horizontal sliding watertight doors, which are electrically controlled from the bridge and hand-controlled from the main deck. In the machinery spaces a CO_2 total flooding smothering system is installed.

Steering of the ship is effected by twin rudders which are supported on fabricated skegs and operated by a four-ram electric hydraulic steering gear manufactured by Brown Brothers and Co., Ltd. In place of the more usual bow rudder the ship is equipped with a Voith Schneider propeller, which has been supplied by the steering gear manufacturers and is fitted in a forward compartment. The propeller, which is controlled from the wheelhouse and the docking bridge by the "Bloctube" system of control rods, works in an athwartship tunnel, about 20ft aft of the stem, which directs the thrust to port or starboard and assists in berthing and unberthing the ship without calling upon the services of a tug. The requirements called for a thrust of 2½ tons and the Mark 14E/90 propeller fitted has a blade orbit diameter of 1400mm, four blades each 900mm in length and is powered by a 250 b.h.p., 440V, three-phase, 60 c/s electric motor which has a full load speed of 870 r.p.m. and turns the propeller at 122 r.p.m.

Clarke Chapman and Co., Ltd., has supplied four electric mooring winches capable of a 30,000 lb pull, and fitted with automatic spooling gear. Two winches are located, one to port and one to starboard, aft on the car deck, another is mounted on the centre line on the docking bridge at the aft end of the upper deck, and the fourth unit is installed right forward on the same deck. Two electric combined warping and anchor capstans are fitted forward on the upper deck with the motors mounted on a flat below, each motor driving a warping capstan and an anchor capstan through gearing and isolating clutches. The sewage plant, which is fitted in the hold space forward of the generator room, has been manufactured by Adams Hydraulic, Ltd.

The galley as seen looking from port to starboard

To prevent corrosion, and the formation of scale in the cold fresh water and salt water piping systems, both of which operate on the "Pneupress" system, the "Guldager electrolytic protection system" has been installed by the Cathodic Protection Company, Ltd. The system was tested successfully in the "Princess Kathleen" and consists of an anode being placed in the water supply so that when electrolytic action occurs the anode is attacked and an anti-corrosive film deposited on the cathode. Cathodic protection is fitted to both piping systems and the anodes, which have a life of about one year, are mounted in reaction tanks incorporated in the system.

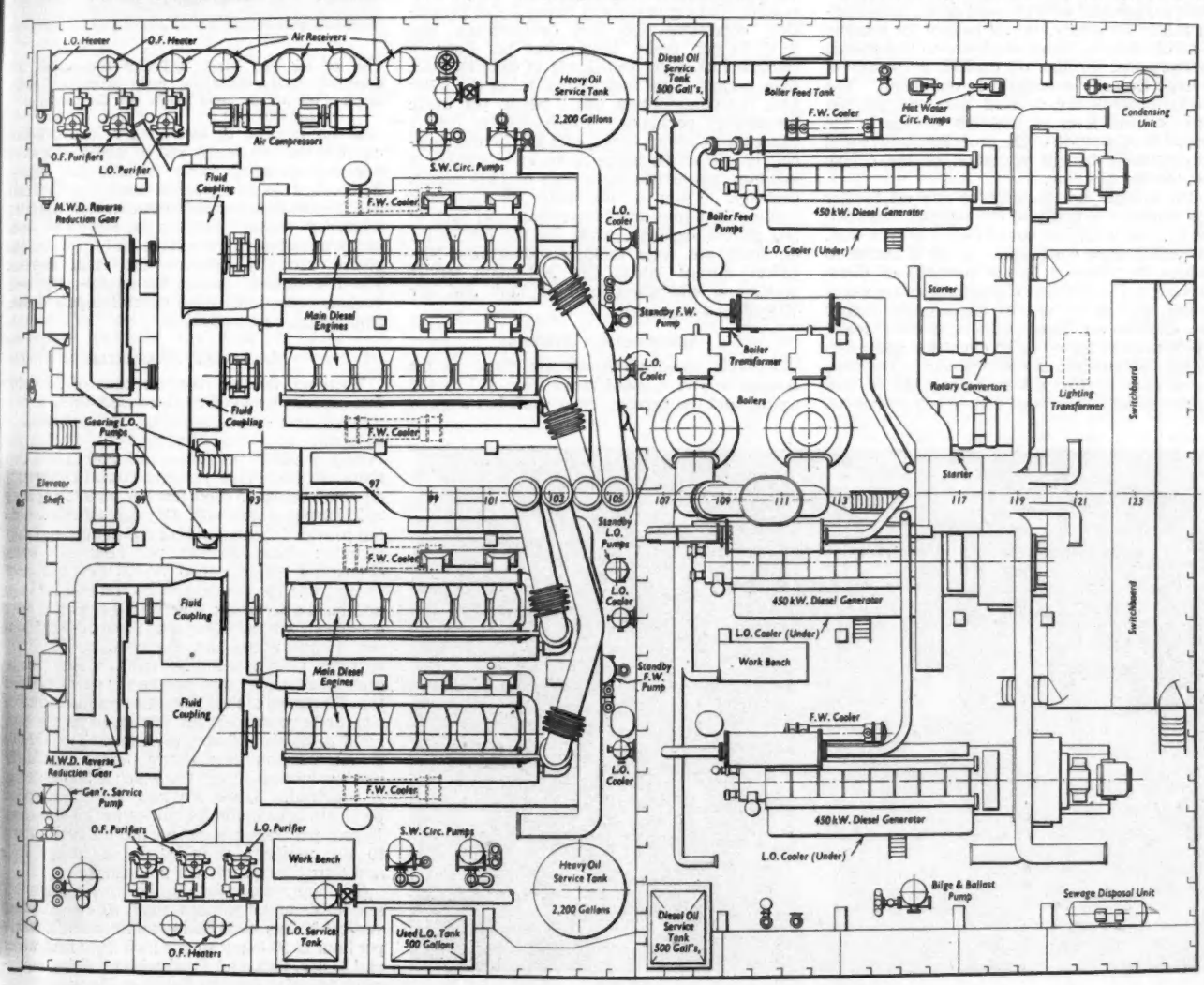
Sufficient life-saving appliances for all on board are provided and there is a total of eight aluminium alloy lifeboats built by Viking Marine Company, Ltd., and seven are equipped with the builders' hand-propelling gear. The boat complement includes six 30ft lifeboats, each having a capacity for eighty persons, and two 26ft boats, one to carry forty-seven persons and the other, which is powered with a Kelvin petrol engine, to carry forty-six persons. All the boats are carried in Stone-Marepa gravity davits with one hand winch per pair of derricks fitted on the bridge deck. In the wheelhouse are various aids to navigation, including a Sperry gyro compass, Kelvin and Hughes magnetic compasses, Marconi echo sounder, radio and radar equipment, and main engine and bow propeller controls.

Main Propelling Machinery

A multi-engine drive arrangement forms the main propelling machinery of the ship and consists of four diesel engines, each pair driving a single propeller shaft through individual Vulcan-Sinclair scoop control fluid couplings, and a Hindmarch/Modern Wheel Drive oil-operated twin input reverse reduction gearbox. Our line drawing shows the arrangement of the main and auxiliary machinery in the engine and generator rooms. The main engines are Mark B4AUM7 units, manufactured by The National Gas and Oil Engine Company, Ltd. They are non-reversing, vertical, four-stroke, pressure-charged, direct-injection engines having seven cylinders of 17in bore by 21·5in stroke. Each engine, which can be seen on test in our photograph, has a normal output of 1750 b.h.p., a one-hour rating of 1925 b.h.p., and a twenty-four-hour continuous rating of 1575 b.h.p. at 333 r.p.m., and is fitted with a Napier "T.S.400" pressure charger, in which the nozzle ring of the turbo-blower has four inlets connected to the four pipes into which the engine exhaust system is split. An intercooler is fitted between the blower and the engine air inlet manifold, and serves partially to control the increase in compression pressure which occurs as the load increases. Engine tests at a brake mean effective pressure of about 140 lb per square inch showed that the heat flow to the circulating water was as low as 1000 B.Th.U. per brake horsepower per hour, the balance being taken out in the intercooler.

The Vulcan-Sinclair size "70" scoop control fluid coupling, supplied by the Fluidrive Engineering Company, Ltd., is carried between the outer pedestal bearing adjacent to the engine crankshaft coupling and the gearbox bearing. By a combination of engine control and the use of the fluid coupling, which is an independent unit, the propeller speed can be regulated down to one-tenth of full speed. This is achieved by reducing the engine speed and then effecting the final reduction by adjustment of the scoop setting to give low propeller revolutions per minute. A high degree of flexibility of speed control is essential to facilitate berthing and to ensure accuracy in track alignment. Another effect of fitting fluid couplings is that torsional oscillations are isolated and each engine can be considered independently from other engines and from the propeller shaft system and, further, the smooth driving torque reduces the loads on gearing and shafting. Operation of the scoop can isolate that particular engine, so that it can be tested without transmitting power to the gearing.

Two identical Hindmarch/M.W.D. oil-operated, twin-input, reverse-reduction, 2 MWR, size 9 gearboxes, manufactured by Modern Wheel Drive, Ltd., transmit the power to the propeller shafts, and with a gear ratio of 1·61 to 1 drive the propellers at 200 r.p.m. One of our photographs shows a gearbox, which transmits 3150 b.h.p. and is driven by two National engines, each of 1575 b.h.p. at 333 r.p.m. The two port engines rotate in a clockwise direction, when looking on the flywheel end of the engine, and the starboard pair of engines rotate in an anti-clockwise direction. The gear is of substantial construction and all wheels are in constant mesh, while both ahead and astern wheels incorporate an oil-operated clutch consisting of inner and outer members. Rotation of the input shaft causes the outer members to revolve, but no power is transmitted until the inner members are brought into working contact with the outer members by means of the admission of oil under pressure into the space between the inner members. Disengagement is effected by the application of oil pressure to the opposite face of the inner members. A pump supplies the oil under pressure and the system consists of a by-pass valve, a control cock and ducts for leading the oil at correct volume and pressure to lubricate working surfaces and to operate the clutches which are controlled by the movement of a lever on the control clock to the "ahead," "stop" or "astern" positions. The control is positive and the change from full



General arrangement of engine and generator rooms in the "Princess of Vancouver"

Looking forward on the car deck towards the four sets of tracks and the hinged side loading doors

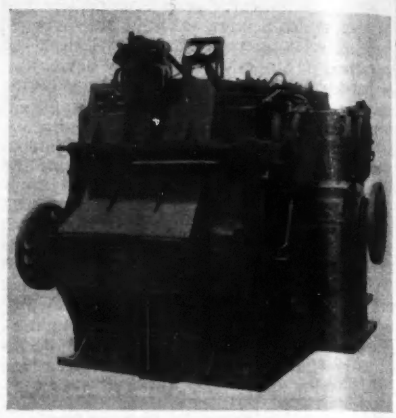
ahead to full astern can be effected in a few seconds.

Any engine can be disconnected, by means of a small lever which operates the appropriate clutch, to effect an emergency repair and then re-engaged without stopping the propeller. To prevent the propellers revolving with the ship under way and with no power being transmitted, the gearboxes are equipped with a braking system fitted to each of the two secondary shafts. The brakes are automatically applied when the main control lever is in the "stop" position and as the pinions of the secondary shafts are in constant engagement with the final drive, the propeller is held stationary. In the base of the gearbox is an oil reservoir from which the oil is delivered to the gears, through oil coolers, by means of a large capacity externally driven pump. The engine controls are coupled with the gearbox main control lever so that any change in the direction of rotation of the propellers is preceded automatically by the reduction of the engine revolutions to idling.

The engines are required to run on bunker fuel having a viscosity of 682 seconds Redwood No. 1, and a sulphur content of 1·60 per cent. To satisfy these conditions, the oil is heated to reduce the viscosity to the standard of diesel oil so that the injection characteristics are maintained, and as an aid to temperature control the engines are fitted with a circular main, which permits the oil to be circulated and reach all the fuel pumps and each cylinder at the same temperature. The oil is centrifuged in two stages, water and foreign matter being removed in the first, and fine foreign matter in the second or clarifier stage. For this purpose, Sharples Centrifuges, Ltd., has supplied four purifiers, and the same company has provided two purifiers for lubricating oil and one for diesel oil. To combat the effect of the sulphur content, chrommium plated liners are fitted, and the bearings are of aluminium alloy resistant to sulphuric corrosion. As another safeguard provision is made to maintain the fresh water in the closed cooling circuit at a temperature high enough to prevent gases from condensing and depositing moisture on the liners. During test bed trials, with the engines running at normal rating under propulsion conditions the fuel consumption was 0·370 lb per brake horsepower per hour of residual fuel, 6 per cent lower in calorific value than normal diesel fuel. When using the latter fuel, the consumption was 0·348 lb per brake horsepower per hour. Heavy bunker fuel is carried in two wing tanks, each of 121 tons capacity, just aft of the engine-room, and there are in addition two service tanks each of 2200 gallons capacity. There is one diesel oil fuel tank holding 22·8 tons and two service tanks each of 500 gallons capacity, while for the lubricating oil there are seven tanks including four 500-gallon storage tanks, one 300-gallon service tank, one 400-gallon used oil tank and one 400-gallon drain tank.

Machinery Controls

Variable speed governors are fitted to the engines to give a speed range from 333 to 133 r.p.m., and the gearbox input shaft has a speed of 323 r.p.m., the corresponding speed of the propeller shaft being 200 r.p.m. Using scoop control the propeller revolutions can be reduced to 21 per minute to give the ship a speed of 3 knots, thus providing a slip of 79 per cent. To change from full ahead to full astern involves seven operations which are regulated over a period by means of a compressed-air-operated time lag mechanism and which occur in the following sequence. The control lever is moved from one position to the other and the engine revolutions drop from 333 to 133 r.p.m., then the fluid coupling scoops are withdrawn to reduce the torque transmitting capacity. Next the gearing clutches are operated so that the gears pass from "ahead" to "neutral" and then from "neutral" to "astern," followed by the lowering of the scoop and an increase in propeller speed. Lastly, with the scoop fully in, the engine revolutions rise from 133 to 333 r.p.m. Only the engine-room staff can shut down an engine



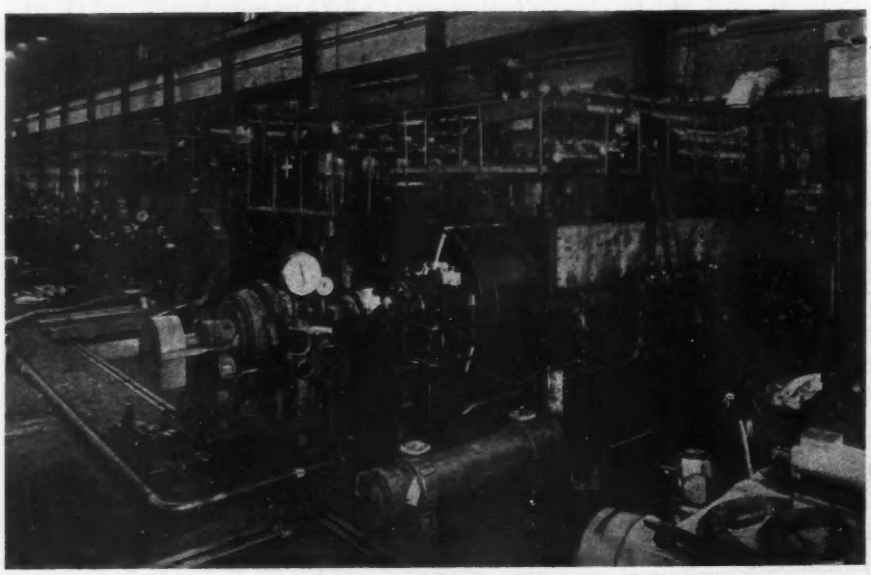
One of the two Mark 2MWR9 twin-engine, oil-operated, reverse-reduction, main propulsion gears, showing one of the input shafts and the output shaft

and this is done by operating a handle which cuts out the fuel pumps and by means of a servo operated isolating valve isolates the engine, fluid couplings and gearbox input shaft. There are six interconnected and pneumatically operated machinery control stations in the ship, three on the main bridge, two on the aft bridge and one placed centrally between the main engines. The five stations outside the engine-room only become operational when control is passed over from engine-room position.

Machinery Auxiliaries

There are five air receivers, each of 31 cubic feet capacity supplied by three electrically driven Reavell, two crank, two stage air compressors, each rated to deliver 24 cubic feet of free air per minute at 350 lb per square inch and in addition there are two Petter radiator cooled emergency air compressors 15 cubic feet per minute capacity at 350 lb per square inch. Drysdale and Co., Ltd., has provided the majority of the pumps and they include :—four 230 tons per hour salt water circulating pumps ; two 70/100 tons per hour pumps, one for general service and one for bilge and ballast services ; one 70/110 tons per hour emergency fire and bilge pump; four 50/90 gallons per minute pumps for domestic and sanitary purposes ; two stand-by fresh water pumps each rated at 85 tons per hour ; two oil fuel transfer pumps each of 50 gallons per minute capacity; and two stand-by lubricating oil pumps each rated to deliver 24 tons per hour. Two 12,000 gallons per hour Hamworthy pumps handle the gearing lubricating oil for which a Serck cooler is provided. There are two heaters supplied by Heatrae, Ltd., for the lubricating oil and three 1½ tons per hour heaters for the oil fuel supply to the purifiers, provided by Swinney, Ltd, and four Sunrod oil fuel preheaters.

To supply steam for the ship's heating system and for domestic purposes there are two Spanner vertical boilers, each having an output of 3000 lb per hour at 50 lb per square inch from feed water at 120 deg. Fah. and fitted with oil firing equipment manufactured by Laidlaw, Drew and Co., Ltd. The boilermaker has supplied three feed



One of the four Mark B4AUM7 main propulsion engines on test at the builder's works

pumps and for circulating the hot water there are three Fulsometer pumps.

The demand for electrical power for lighting, domestic services and for driving the deck and auxiliary machinery is met by three Brush alternators, installed in a separate generator room, each having an output of 450kW, 450V, three phase, 60 c/s, and a power factor of 0·8. Each alternator is driven by a mark F4A8 National oil engine, which has eight cylinders of 12in diameter by 15in stroke, and is fitted with four valve cylinder heads and develops 780 b.h.p. at 514 r.p.m. The fuel system is identical with that arranged for the main engines, and on test the average fuel consumption of heavy fuel was 0·373 lb per brake horsepower per hour. Each alternator is fitted with an automatic voltage regulator and a synchronising panel, and sychronising is facilitated by a remote control switch which permits the governor speeder spring to be regulated to synchronise the speed of the incoming machine to that of the system. Heavy duty Burgess silencers are fitted and also Serck fresh water and lubricating oil coolers. Whipp and Bourne, Ltd., has provided the main switchboard, which is mounted on a flat at the forward end of the generator room, the space being enclosed. Also installed in the generator room are two Laurence Scott rotary converters. For emergency purposes there is an emergency generator set installed in a compartment in the house on the bridge deck. The set consists of a flange-mounted 150kW single-bearing Brush alternator driven by a mark M4AA8 National oil engine having eight cylinders of 6in diameter by 8½in stroke and developing 265 b.h.p. at 1200 r.p.m. Starting is by compressed air and the unit is mounted on an underbase with a Serck radiator, and a centrifugal water circulating pump integral with the engine. The emergency switchboard is in the compartment and there is also a Foster transformer.

To reduce the noise level in both engine and generator rooms all the steelwork above the floor level of these spaces is covered with sound-absorbent insulation consisting of 2in Stillite sheathed with perforated sheet steel. Ventilation of the engine-room is effected by two 38in diameter Aerofoil fans, each capable of delivering 26,250 cubic feet of air per minute, while two similar fans, but of 10,750 cubic feet per minute capacity, supply the generator room, all the fans being supplied by Woods of Colchester, Ltd.

Driving the Allt-Na-Lairige Tunnel

THE contractor for the North of Scotland Hydro-Electric Board's constructional scheme at Allt-na-Lairige, in Argyll, recently claimed a record for the speed at which the tunnel was driven, namely, 444ft in seven days. A brief outline of the tunnel driving procedure is given here.

The tunnel is only 8ft high by 6ft 6in wide and had to be driven through granite. This small section, and the nature of the rock, made a pull of much more than 7ft to 8ft per cycle unlikely, but it was decided, despite these somewhat unfavourable conditions, to attempt a high-speed face advance. Attention was directed to the drilling and mucking parts of the cycle, which take a high proportion of the total cycle time. Air pressure was substantially increased, supply pressure being raised from a normal 80 lb per square inch or so to 115 lb per square inch at the face. The rock drill is already a highly stressed piece of equipment, but it was decided that the risk of premature breakages was worth taking. Holman "Silver 3" Airleg mounted "Handrils" were chosen for this work and three machines were employed to drill the average twenty-one hole pattern with a further three standby machines used in rotation. At the completion of the tunnel each machine had drilled approximately 30,000ft and spares consumption was no more than usual with any rock drill at normal air pressure, it is stated.

Tungsten-carbide-tipped "Holsteels" of ⅞in hexagon section with 1½in diameter bits were employed. To avoid loss of time on changing, 8ft steels only were used throughout. The severe combination of hard rock and heavy blow with vibration of the long, unsupported rod, resulted in high fatigue stresses, tending to shorten the life of the steels, but a check near the end of the work indicated that the average life was then about 300ft, which, in the circumstances, was considered to be good.

It was found that the 8ft holes could be consistently drilled in just over four minutes, and the overall drilling speeds (including time for moving from hole to hole) were 18in to 20in per minute throughout the work. Total drilling time was thus cut to under thirty-five minutes per cycle.

Broken rock was loaded out with the well-tried "Eimco model 21 Rocker shovel." The tunnel size is about the minimum for this machine and the loading rate was high, particularly with the increased air pressure, but overall speeds are dictated largely by the facilities for removing spoil. The width of tunnel here prevented any possibility of fast car changing. It was felt that any of the usual methods of car changing result in more loss of time than is generally recognised, and it was expected that a special shuttle car with a capacity at least equal to the quantity of rock removed in one complete cycle would ensure continuous loading out. The car is shown in the illustration; the main frame is 70ft long and is carried on two eight-wheel bogies. The chassis is supported on stub axles integral with the bogie frame. The floor of the body consists of a steel slat conveyor belt on rollers, propelled by hydraulic rams. The loaded rock is thus moved steadily back as required to make room for the new fill.

Some doubt was felt as to the amount of friction which might occur between the stationary side plates and the moving rock because the load moves as a rectangular mass about 3ft deep between the vertical side walls, which are 4ft 6in apart. Besides the possible difficulty of coping with stress and wear, trouble was anticipated because it was thought that rock at the sides would move more slowly than that in contact with the belt. A half-scale experiment was, therefore, carried out which indicated that these fears were groundless. Only a moderate pull was required on the belt of the full-size car and rock movement was entirely satisfactory. The load was discharged through a space at the bottom of the car at the rear, in this particular case into tubs of 2 cubic yards capacity, as illustrated. Satisfactory working of the car was not achieved without various delays and modifications, and several thousand feet of tunnel were driven by normal loading-out methods, using small cars and passing bays. Mucking times before and after the introduction of the special car make an interesting comparison. The best time of about eighty minutes was reduced to forty minutes for the same depth of pull.

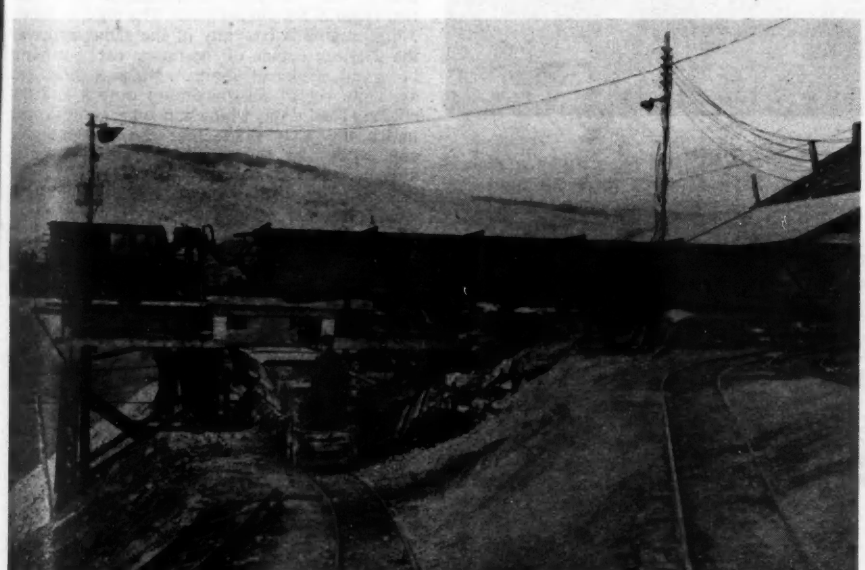
The behaviour of such a large car on the track inside the tunnel was a possible source of trouble. No special care was taken in laying the 2ft gauge track of 30 lb rails, but running on the carefully designed bogies proved to be very smooth at speeds up to about 8 m.p.h., both laden and empty. Curves of a minimum radius of about 120ft can be negotiated. Towing was by a modified version of the 38 h.p. "4DS–U" diesel underground locomotive, supplied by F. C. Hibberd and Co., Ltd., who also collaborated in designing the remote controls which could be operated from the loading end of the car—70ft away. Hydraulic power for the conveyor belt was taken from an engine-driven pump incorporated in the locomotive.

Still further time was saved by the high capacity of the ventilation system. The supply was stepped-up to the exceptional figure, for this face area, of 7500 cubic feet per minute operating at a pressure of 60in water gauge. Two Holmes lobe blowers of 35 h.p. and 85 h.p. were used. Both were run to clear gas after blasting and during the mucking period; re-entry to an entirely smoke-free face was possible within ten minutes after firing. Diesel fumes were also cleared by this system. Ventilation and compressed air pipes were chain-slung from the roof.

Other aspects of the work followed normal practice. Although shorter working hours might have improved times still further, the usual twelve-hour shift system was employed. Face labour requirements were small, the crews being made up of nine men as follows:—One shift boss, three drillers, two spanner men, one loader operator, one loco driver, one handyman.

By the time the shuttle car was in regular service, cycle times were so short that an attempt was made at an optimum figure for a working week. During the seven-day period commencing March 31st, sixty-seven cycles were completed, despite loss of more than a shift on rectifying minor faults on the car. In the seven days the tunnel was driven 444ft. This substantial improvement on the figure of 428ft then standing is claimed as a record. Had the tunnel not then been almost finished, further improvement could have been reasonably expected. The results validated the somewhat expensive experimental work on the large shuttle car.

The North of Scotland Hydro-Electric Board's consultants for the scheme are Messrs. Babtie Shaw and Morton, and the contractor is Marples Ridgeway and Partners, Ltd.



Disposing of spoil at the tunnel portal. The shuttle car is 70ft long and has a steel slat conveyor belt. The entire quantity of spoil in one cycle is loaded at the right hand end of the car. The car is then hauled out and discharged as shown

German Racing and Sports Cars

THREE Mercédès-Benz racing sports cars, three standard sports cars and three diesel cars of the same company were the winners and the fastest cars in their respective classes at this year's Italian motor road race, the "Mille Miglia." Certain particulars of the petrol engined cars are now available.

The 1·8-litre diesel and the 3-litre standard sports cars are no newcomers to this country, the latter having been exhibited for the first time in this country at last year's London Motor Show. Displayed as a two-seater coupé, this type aroused considerable interest as being the first production car ever fitted with an engine equipped with petrol injection. As the car was described in detail in the Motor Show report of THE ENGINEER of October 29, 1954, it is sufficient to repeat the main specifications of the six-cylinder engine of 3 litres capacity; it has a bore of 85mm, a stroke of 88mm, a compression ratio of 8·55 : 1, and develops 240 b.h.p. at the maximum speed of 6100 r.p.m. The high average speed of 87 m.p.h., maintained by the winner for more than thirteen hours, seems to prove that on straight roads this type is indeed capable of a maximum speed of 165 m.p.h., as is claimed by the makers.

The "Mille Miglia" racing sports cars, though having the same cylinder capacity as the standard sports cars, are of entirely different construction. Designed to compete in the international sports car events of this year they are similar in appearance and in their general layout to the 2·5-litre racing cars which made their first appearance in this country last year at the Grand Prix race at Silverstone. Figs. 2 and 3 show the general layout of the racing car: it has a light tubular frame, the individual members of which are subject to compressive and tensile stresses only, but not to bending. All wheels are independently sprung: the front suspension has double wishbones of uneven length, torsion bars and telescopic dampers, the rear suspension consists of a double-jointed swing axle, also supported by torsion bars with telescopic dampers. The engine torque is transmitted via a dry single-disc clutch and an open propeller shaft to the five-speed fully synchronised gearbox, which is integral with the final rear-axle drive and is attached to the frame by means of rubber mountings. The brakes, at the front as well as at the rear, are detached from the wheels and are arranged inside the frame; the brake torque is transmitted to the brake drums at the rear by the drive shafts of the swing axle and to those at the front by universally jointed shafts. The unusually large brake drums are of light metal with cast iron liners and are fitted with radial cooling vanes to increase the circulation of the air which enters the body through an elaborate ducting. These ducts also ventilate the cockpit and lead cooling air to the rear tyres.

The 2·5-litre, eight-cylinder engine is mounted in a tilted position to secure a low bonnet line. It is equipped with petrol injection, dual magneto ignition and dry sump lubrication, the torque being taken off through gearing from the middle of the crankshaft, which is carried in roller bearings. Little information is available of the constructional details of the engine, which has a bore of 76mm and a stroke of 68·8mm, and is believed to develop about 300 b.h.p. at more than 8000 r.p.m. The high engine speed is ascribed to a new valve operating design whereby the valve closure is not effected in the orthodox way by means of springs, but by positive cam action, a system which would avoid spring surge and other undesirable consequences arising from spring behaviour at high speed.

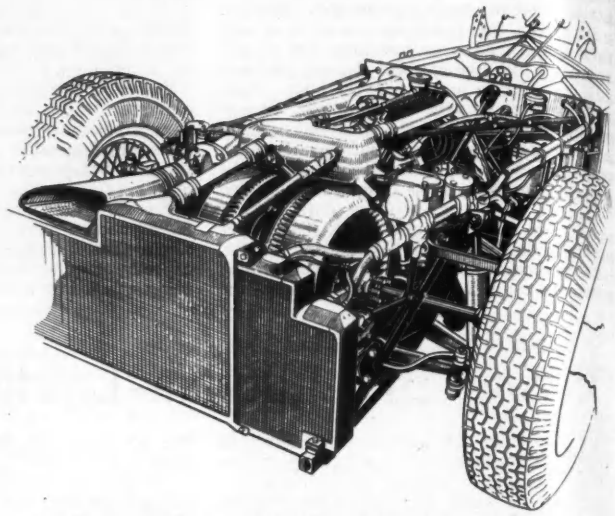


Fig. 3—Mercedes-Benz 2·5-litre "Formula" racing car showing engine compartment, shaft brakes, water and oil cooling radiators

Fig. 1—Mercedes-Benz 3-litre racing sports car

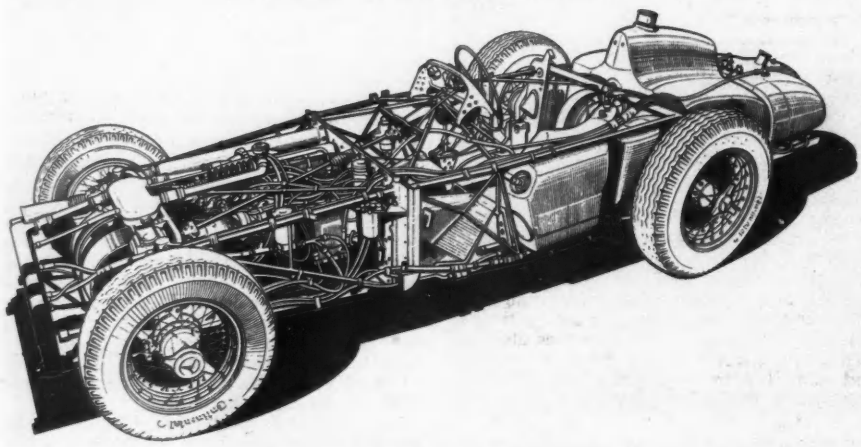


Fig. 2—Mercedes-Benz 2·5-litre racing car

The single-seater car weighs dry 1500 lb. It is equipped with a light-metal body, either streamlined for racing on mainly straight roads or in a modified shape without wings in order to allow the driver to watch the position of the front wheels when cornering. The size of the tyres to be fitted to the 16in spoke-wire wheels varies according to the local conditions of the respective race courses.

Fig. 1 shows the two-seater version of the new 3-litre racing sports car, type "300 SLR," the general conception of which is clearly influenced by the design of the 2·5-litre racing car. Apart from such modifications as are necessitated by the requirements of road racing—for instance, lighting equipment, servo-assisted hydraulic brakes, &c.—the main difference between these two types is the engine size. The eight-cylinder, 3-litre engine is basically of the same layout as the 2·5-litre engine of the racing car, but has a bore and stroke of 78mm. No particulars are available yet of the maximum output and the engine speed data, which can only be estimated under the assumption that the eight-cylinder engine of the racing sports car will probably not be very much more highly stressed than the six-cylinder power unit of the standard sports car. The latter has a mean piston speed of about 3600ft per minute and a maximum brake mean effective pressure of about 180 lb per square inch at 4800 r.p.m. Assuming the piston speed and the mean effective pressure to be the same in both engines, the maximum speed of the short-stroke, eight-cylinder works out to about 7000 r.p.m. and the output to about 275 b.h.p. In reality, maximum output and maximum speed might easily be slightly higher as the eight-cylinder engine is equipped with the new positive valve-operating gear, which should allow a higher engine speed. The two-seater car, fitted with racing tyres of 6·00×16 at the front and 7·00×16 at the rear, weighs dry about 1800 lb, the one-seater version is slightly lighter. It is reported that the maximum speed on straight roads attained during the "Mille Miglia" was in the neighbourhood of 177 m.p.h., and that an average speed of about 107 m.p.h. was maintained by the winner for the first five hours of the race.

Hydraulically-Operated Platform for Overhead Working

THE accompanying illustrations show a mobile platform, which is mounted on a lorry and can be extended to any desired working position, within a maximum height of 40ft and a reach of 25ft. The platform is made by Simon Hydraulic Machinery, Queen's Cross, Dudley, Worcestershire, a branch of Thomas Adshead and Son, Ltd., and it is known as the Simon hydraulic platform. As may be observed, it comprises a turntable base, with two booms linked above it, which may be "folded" or opened by the operation of hydraulic jacks. The platform itself is hinged on the end of the upper boom, and is maintained horizontal in any position by a simple linkage. The platform can be controlled by the operator working on it, or from the ground. The booms are each 20ft long and can each be moved through practically 90 deg. by their respective hydraulic jack, so the platform has a considerable degree of mobility and can be manœuvred into restricted positions.

The side elevation of the whole assembly shows the mounting base *A*, which is bolted directly on to a truck chassis or any other mobile unit. The upper portion carries two rings *B*, one above the other, their purpose being to form a way on which run a number of rollers *C*, thus assisting in carrying the overhung loads imposed by the booms and platform. The rollers are disposed radially about the central mounting shaft which locates the upper turntable assembly *D* so that it may be power rotated by a roller chain which is attached to the internal diameter of the lower ring *B*. The roller chain engages with a sprocket on the vertical shaft of a worm reduction gear *E*, which is in turn powered by a hydraulic vane motor, deriving its pressure fluid from a central pumping station at *F*.

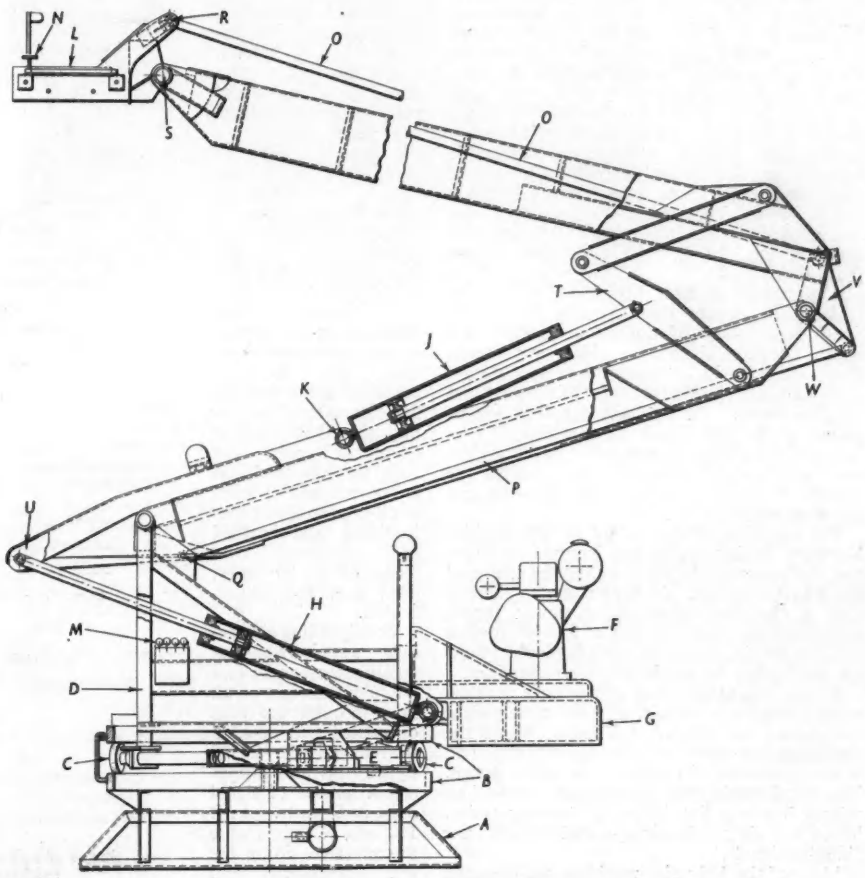
A mounting platform and oil reservoir *G* is carried on the upper turntable. It carries an 8 h.p., two stroke internal combustion engine running at 1500 r.p.m., which is coupled directly to a vane hydraulic pump. The hydraulic pump is a fixed delivery machine, giving 5 g.p.m. at 1500 r.p.m. A maximum pressure of 1200 lb per square inch is preset by a simple spring-loaded relief valve in the system. This pumping unit supplies pressure fluid for all the motions of the platform, viz. : the turntable rotations, the 5in cylinder *H* operating the lower boom, and the 6in cylinder *J* operating the upper boom. These cylinders have a stroke of approximately 36in. The platform *G* and its load act as a balance weight to the overhung loads which occur when the booms reach over in the normal course of operation.

One end of each cylinder is mounted on a shaft *K* which serves a dual purpose ; it carries the loads from the cylinder and is also cross drilled, enabling pressure fluid to feed into the cylinders through the shaft, thus dispensing with flexible hydraulic pipes and giving a consequent increase in reliability. Fluid is fed to both sides of the pistons and there is provision in the design to restrict the fluid flow so as to limit the speed of rise or fall. In this way the sudden failure of a hydraulic pipeline would not result in a collapse of the structure. Furthermore, if the main driving engine fails the fluid is then hydraulically locked within each cylinder and the platform *L* remains in position, until operation of the control valves allows the booms to descend slowly. The control valves for the hydraulic circuit are duplicated—one set being manually operable from the turntable at *M* and one set being foot-operated from the platform at *N*. There is also a push button which brings the whole unit to a halt by shorting the ignition of the main drive engine. Piston valves afford a degree of sensitivity to the boom movements and relief valving ensures that the system is unloaded above the fixed pressure. The rise and fall of each boom is controlled by foot pedals and rotary movement of the turntable is knee-operated.

All the hydraulic lines are of seamless tubing. In use the main engine and pump circulate oil freely at low pressure until valve operation directs the flow to the cylinders or hydraulic motor. Resistance at these points causes the pressure rise to the maximum of 1200 lb per square inch, while excess fluid is passed to exhaust. Directly the required platform working position is reached the operating valve is released and the cylinders are hydraulically locked.

The upper and lower booms are of box section, fabricated from light gauge pressings, 20ft long steel sheets being formed on a brake press.

On the extremity of the upper boom is the platform *L*, which carries the payload. The platform is maintained horizontal by the levelling rods *O* and *P*. These rods are exactly the same length as the booms between joints and they are pinned at *Q* and *R* (the platform itself is pinned at *S*) and at the arm *V*, which is itself pinned at *W*.



Elevation of hydraulically-operated working platform

The movement of each boom is practically 90 deg. from the horizontal rest position, so that maximum working height, with one boom almost vertical on the other, 40ft is easily reached ; the maximum reach-over position with the lower boom vertical and upper boom horizontal, gives a height of approximately 23ft and a reach or working radius of 25ft. The effective stroke of each piston and cylinder *H* and *J* is 36in, and it will be observed that this movement is stepped up with the folding linkage *T* for the upper boom and the simple boom extension *U* for the lower boom.

Besides the hydraulic duties which the main pumping section undertakes, there is an additional duty which is needed when the unit is mounted on a truck chassis. The normal rear axle suspension is locked solid by a latch lever which is operated by a hydraulic cylinder. Upon arrival at the site one of the first tasks is to operate a piston valve on the turntable so that the latch swings radially and connects with the rear axle, thus eliminating the normal suspension and making the parent vehicle a rigid base from which to operate.

Platform in operation with both booms partially extended

Colour-Light Signalling on the Southern Region

ON the morning of Sunday, May 8th, colour-light signalling was inaugurated between East Croydon and Coulsdon North on the Southern Region of British Railways. This completes the fourth and final stage in providing continuous colour-light signalling between Victoria, London Bridge and Brighton. The line involved and that completed in the three previous stages can be seen in the diagram we reproduce.

The fourth stage of the scheme included the provision of three new signalboxes containing all-electric lever frames at East Croydon, South Croydon and Purley and sixteen automatic sections covering twenty-three track miles of continuous track circuiting. At the London end this stage joins up with that at Gloucester Road Junction, brought into use in 1954, and between Purley and Coulsdon North it meets the Brighton line colour-light signalling system. The area concerned carries all trains to Brighton and other nearby South Coast resorts from both London Bridge and Victoria and very considerable suburban services to the Tattenham Corner and Caterham branch lines, which leave the main line at Purley. There are also services to Coulsdon North and many intermediate stations on the Brighton line. In all, 5600 trains pass through the area in a week.

A signalbox at East Croydon (103 levers) replaces the present East Croydon North and South boxes, each of eighty-four levers. The South Croydon signalbox (thirty-one levers), illustrated herewith, replaces the present station and junction signalboxes of thirty-two and fifty-five levers. Purley Oaks signalbox will be abolished, the new signals between South Croydon and Purley being automatic. At Purley the new signalbox (seventy-one levers) replaces the present North and South boxes (fifty-two and fifty-four levers).

The signalbox structures are of the familiar Southern Region design and incorporate stores and staff accommodation as well as the relay and accumulator rooms. At East Croydon there is also a chamber incorporating power supply equipment for signalling, but at South Croydon and Purley the signalling supplies (440V, 50 c/s) are taken from the nearby traction substations.

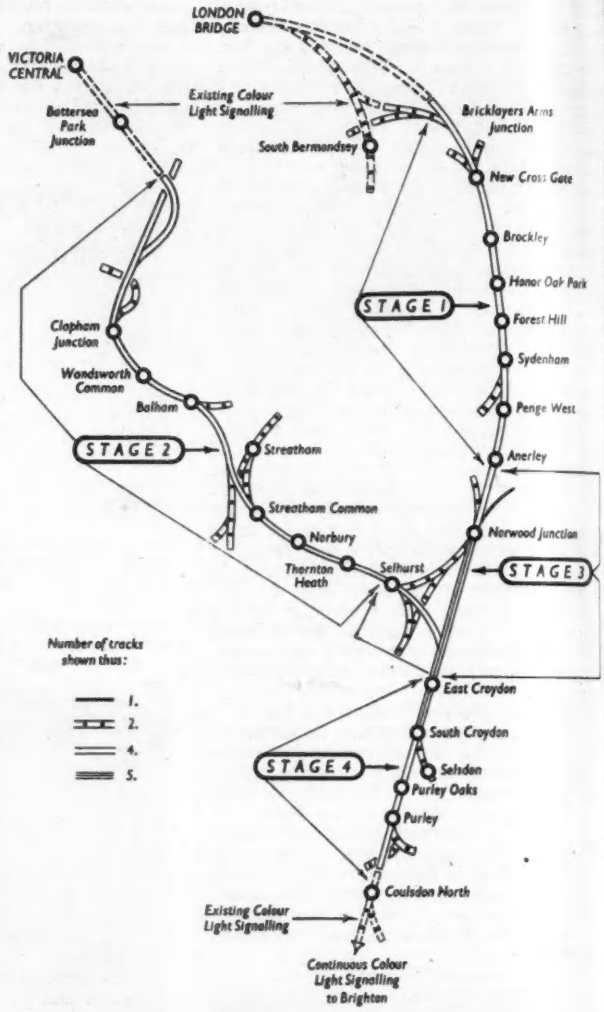
In the installation there are seventy multiple aspect, long range signals, of which twenty-eight are carried on tubular steel posts, whilst the remainder are carried on nine signal bridges and seven structures of cantilever or other design. The signal spacing provides for a two-and-a-half minute headway for following stopping trains. There are sixty solenoid-operated floodlit disc shunting signals.

Most of the 100 point machines are operated from 120V accumulator batteries at the three new signalboxes, the batteries being trickle-charged by rectifiers. There are also stand-by rectifiers at these boxes for direct point operation if necessary. Telephones connected to separate circuits provided at all the automatic and most of the controlled signals, give train crews direct communication with the signalbox concerned.

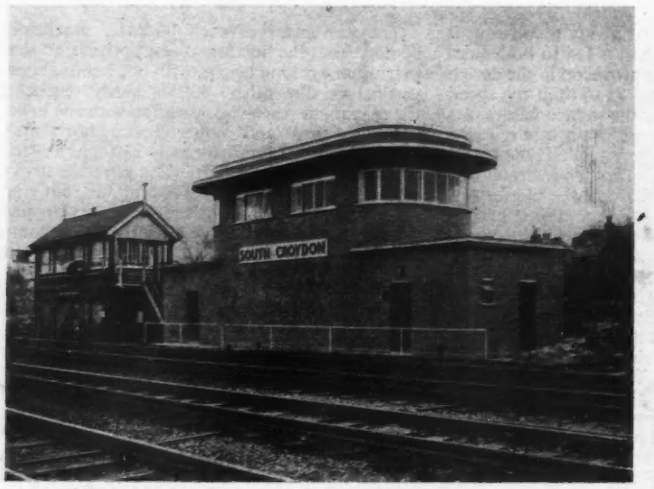
There are 130 condenser fed track circuits, single and double rail incorporating 145 impedance bonds. The track relays are, where possible, located in the signalbox relay rooms, local controller rooms, or the apparatus cases of automatic signal locations. The cable route, some 10 miles long, is almost throughout in surface concrete troughing and multi-core V.I.R. lead-sheathed, protected and served signalling cables have conductors varying in number from ten to forty. The work called for approximately 550 core miles of signalling cable, 85 pair miles of telephone cable, dry core lead-sheathed and armoured, and 4½ miles of oil-impregnated paper insulated lead-sheathed and armoured twin feeder cables for 480V, 440V and 110V distribution.

The signalling changeover was carried out within a seven-and-a-half hours' possession of all lines through the area concerned and entailed the removal of over 120 signal arms and fittings and a number of signal dolls and posts. In it 100 sets of points were disconnected from the old signalboxes and reconnected to the electric point machines which had been previously installed and tested.

The work involved in the whole scheme, extending from Battersea Park and Bricklayers Arms Junction to Coulsdon, has been spread over six years and the installation has cost about £2,000,000. In the scheme eleven new signalboxes containing all-electric power frames replace thirty-two manually worked signalboxes over an area of 117 track miles (27 route miles). There are 400 multiple-aspect signals, nearly all four-aspect, of which 100 are automatic, and



Stages of colour-light signalling, Battersea Park Junction and Bricklayers Arms Junction to Coulsdon North



New signalbox at South Croydon with the old box on the left

Signalling floor thirty-one-lever power frame in signalbox at South Croydon

the general signal spacing (sections 440–1000 yards) provides for a two to two-and-a-half minute headway for following stopping trains.

Carrying the signals are twenty-two specially designed lightweight signal bridges, spanning four or five tracks, thirty-three concrete structures of 11ft to 13ft 6in overhang, and a number of other cantilever structures in welded steelwork of overhangs between 12ft and 24ft. All these structures were designed and erected by the Chief Civil Engineer, Southern Region. Wherever possible signals are carried on tubular steel posts provided with galleries.

Over 600 condenser fed, single rail and double rail track circuits, which have been installed, entail nearly 800 impedance bonds. There are 175 electrically-operated floodlit shunt signals, and 400 all-electric point machines. Magazine train describers have been fitted throughout, there being 127 sets of transmitting and receiving equipment with twenty-one sets of power equipment, each comprising lead acid accumulator batteries and automatic charging rectifiers.

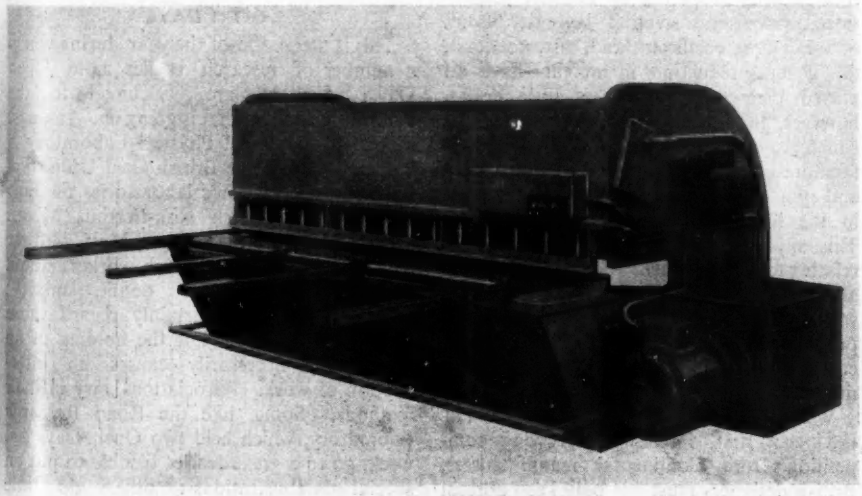
The scheme was prepared and the whole of the installation work carried out by staff of the Southern Region Signal Engineer, Mr. L. J. Boucher, under his New Works Assistant, Mr. C. F. Challis.

Guillotine Shearing Machine

A HYDRAULICALLY-OPERATED guillotine shearing machine made in two sizes with capacities of 10ft by ⅜in and 8ft by ½in, by T. B. Pearson and Sons, Ltd., Wincomblee Road, Newcastle upon Tyne, is illustrated below. These machines are of welded plate construction.

Hydraulic power for operating this machine is supplied by a multi-cylinder radial hydraulic pump driven by a 25 h.p. squirrel-cage motor. The ram assembly carrying the upper set of blades is mounted on trunnions carried on roller bearings in the side members of the machine. This ram is actuated by hydraulic cylinders and in the shearing operation the blades pass through a wide arc. In this way, as the shearing operation is completed, the upper blades swing clear of the lower blades to reduce friction and consequent wear on both sets of blades. The admission of hydraulic fluid to the ram cylinders is controlled through a pedal bar along the front of the machine. At the end of the shearing stroke an automatic switch changes the main hydraulic control valve to exhaust and the return stroke is automatically carried out by a separate gas pressure cylinder.

A push-button-operated back stop fitted to the machine has a maximum setting of 30in and inset scale strips are fitted to the table front extension arms. Rollers set in the table top facilitate the handling of heavy plates, and hydraulic damping jacks are built in behind the guard.

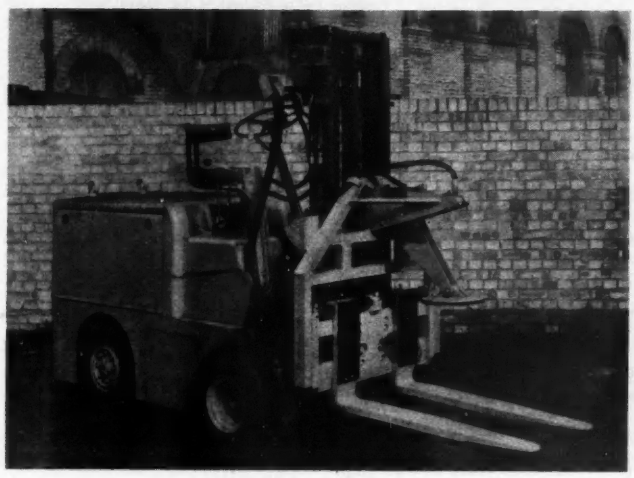


Hydraulic guilliotine shearing machine

Fork Truck Load Steadying Device

To provide an effective means of "locking" bulky and out-of-balance loads to the forks of fork trucks, or steadying difficult loads when traversing uneven surfaces, a simple hydraulically operated steadying device has been developed by I.T.D., Ltd., 95/99, Ladbroke Grove, London, W.11.

The new device, as can be seen from the accompanying illustration, consists of a rigid supporting frame structure which replaces the conventional backguard of the truck. Mounted centrally at the apex of the support structure is a cantilever bracket within the side plates of which is enclosed a simple system of levers and a double-acting hydraulic ram. Through the levers the ram actuates a clamping arm at the lower end of which there is pivoted a large plate. By operation of a two-way control valve the double-acting ram can be actuated to produce movement of the clamping arm and apply or release the steadying pressure of the plate upon the load.



Hydraulically-operated load steadying device fitted to a fork lift truck

Immersion Vibrator for Compaction of Granular Soils

A METHOD of compacting granular soils by the use of a large immersion vibrator, which is operated with water jets, has been introduced to this country. The method was invented in Germany and has been used extensively in the United States; rights for its use in Great Britain have been acquired by Vibrofounds, Ltd., Ruislip Road, Southall, Middlesex, a company in the Taylor Woodrow organisation.

The vibrator is 6ft long and 15in in diameter. A totally enclosed electric motor of 35 h.p. within the vibrator drives a 400 lb eccentric which gives vibrations of 30 c/s frequency and 1¼in maximum amplitude. The motor is capable of sustaining 100 per cent overload for short periods. Water jets at both the top and the bottom of the vibrator are utilised. An adaptor section 12in in diameter fastens above the vibrator to give the required depth of penetration and the whole assembly, including suspended guide rails, is slung from a crane jib. Its weight is about 2 tons for a total length of 12ft.

As the vibrator is lowered into the soil, the bottom jet is opened, and the soil immediately below it becomes saturated; the vibrations induce a "quick" condition, and the machine penetrates under its own weight. Compaction of material around the vibrator then takes place, but a cone-shaped crater is also formed at ground level and additional material is shovelled into the crater to compensate for the increased density of the compacted material. When the vibrator reaches the desired depth the bottom jet is closed, and the top jet opened; then it is raised 1ft at a time and the hole backfilled with additional material. Depths from 8ft to about 35ft or 50ft may be compacted in this way, giving a compacted column 8ft or 10ft in diameter, the firm states. The method is claimed to have useful application in granular soils, where an increase in the density and the angle of internal friction gives enhanced load-bearing properties, and also in some other consolidation processes. The degree of compaction depends on factors such as the relative density, voids ratio, and particle grading of the granular soil concerned, but a check on the degree of consolidation achieved is given by the recording ammeter of the machine, the power output being related to the consolidation for a given soil and depth of penetration.

Mines and Quarries

THE report of H.M. Inspectors of Mines and Quarries for 1953 has just been published and it shows that the number of persons employed at quarries during the year averaged 61,250, including 7934 at opencast coal workings. The total output of mineral was 165,493,000 tons, including 11,704,000 tons of coal, and 250,700 tons of fireclay. On the subject of mechanisation and development, the report points out that mechanical loading of materials at the face continued, but, as might be expected, at a greatly reduced rate, as a majority of the larger concerns were already fully mechanised and most others employed loading machines. From a safety aspect the advantages of mechanised loading were strikingly illustrated when comparing the numbers of fatal and reportable accidents from falls of ground which occurred in the five year periods 1927–31 and 1949–53. In the first period 136 persons were killed and 391 reportably injured as compared with 67 and 128 respectively in the second period. A further device has been introduced to give additional protection to operators of drills working at the foot of the face. It is a drifter drill which can be controlled pneumatically up to a distance of 45ft from the face, and has marked advantages when drilling near steep face sections. The report deals in some detail with the causes and results of a number of avoidable accidents which entailed loss of life or injury to workers.

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MOTOR RACING

In spite of the lack of interest in motor racing in this country, it is satisfactory to note that the success of Stirling Moss in the twenty-second Mille Miglia—Italy's most important road race—has been greatly welcome by the general public. Driving in his first Continental race since he joined the German Mercédès-Benz team, Stirling Moss earned the distinction of being the first Briton and only the second non-Italian to win the Mille Miglia, a race which is generally considered the most difficult in the international calendar. At the wheel of a 3-litre Mercédès racing sports car, Moss covered the 992-miles-long route, leading from Brescia in North Italy, towards Rome, and from there back to the starting point, in 10 h 7 min 48 sec., beating his stable companion Fangio by thirty-two minutes. His average speed of 97·8 m.p.h. broke the previous record set up two years ago by the Italian Mazotti in a Ferrari, who averaged 88·2 m.p.h.

For the vast crowds which line the roads at a race like the Mille Miglia the contest is generally not much more than a gigantic spectacle in which drivers, many of them of international reputation, match their skill and daring. The engineer, however, is more inclined to consider motor racing as a true and conclusive test of machines, a test in which designs and materials are strained to the utmost for the purpose of proving the soundness and the reliability of the underlying constructional principles. Analysing, for instance, the results of this year's Mille Miglia, it may surprise many engineers to realise that (with one exception, a 3·7-litre Ferrari car which finished third in the class of the racing sports cars) the fastest cars, i.e. the two winners of the racing sports cars and the three winners of standard sports cars of more than 1300 c.c. cylinder capacity, were characterised by such constructional details as fuel injection, all-wheel independent suspension, in-board brakes, &c., design details which are still regarded as unorthodox in British automobile engineering. Also, the diesel engine, which is only slowly and rather reluctantly finding acceptance in this country, has proved at this year's Mille Miglia a serious competitor to the petrol engine. The three winners of the "diesel class" were 1·8-litre cars of a make which for many years has been very popular on the Continent; the average speed of the first winner, amounting to 59 m.p.h., compares favourably with that of equivalent petrol engines, and equals the record speed attained twenty-three years ago on the same route by Carraciola on a Mercédès racing sports car. It would be wrong to attribute the greatly increased average speed of all sports cars at this year's race entirely to higher specific engine performance; other factors—in particular, improvements in the handling and road-holding properties by effective suspensions, stabilisers, steering layouts, bodies of lower drag coefficient and, last, not least, the general reduction in weight—have all played their part. There is little doubt, however, that most of the technical details which to-day are either entirely or preferentially used for high-performance racing and sports cars will eventually gain entrance in the field of standard production cars. This applies in particular to improvements relating to engine design. In this field research and development have slowed down, since, with the advent of the gas turbine for aircraft propulsion, development of the automotive engine has fallen nearly entirely upon the motor industry.

We have frequently pointed out in THE ENGINEER that, faced with growing competition from Continental manufacturers, British designers must not only keep abreast of engineering progress, but should be ahead of current ideas. And what better opportunity is there for trying out the value of new ideas than racing our latest and most modern products against those of our competitors! It has been argued that the results of racing are not necessarily conclusive, that experience gained in this way is hardly applicable to standard production cars, and that better or, at least, more accurate information could be attained by prolonged rig tests. There is, of course, some element of truth in these arguments, but even the strongest advocates of the rig-test method will hardly deny that, after all, the real crucial test for road vehicles is quite naturally the road test. Why, then, should we not go one step further and conduct these tests not in the seclusion of more or less private testing grounds, but in public, i.e. in competition with other manufacturers, thus showing supreme confidence in the soundness and reliability of designs which are to stand the test! It may be open to doubt whether the high expenditure of competing in international events, especially in Grand Prix racing, is justified as an ordinary commercial venture. However, Italian and German firms have been using this policy with advantage not only to further the technical development and the performance of their cars, but as one of the most effective forms of industrial propaganda. It seems regrettable that this method of demonstrating the inventive genius of our engineers and the capacity of our motor industry should go so long neglected by this country. The fact that since the war some British racing cars have been constructed, either by private sports enthusiasts or by comparatively small firms (sometimes with entirely inadequate means), does not materially alter the picture. Commendable as these attempts may be, they have not been able to achieve their main objective, namely, to further the future development of the motor-car and, thereby, the prestige of the industry as a whole. The construction of successful racing and racing sports cars should be left to big progressive firms with a first-class design staff and ample manufacturing facilities, firms which are able and willing to utilise fully the knowledge and experience gained in racing practice by incorporating the best features of racing car design in their standard production models.

OPEN DAYS

This is the season of the year during which a number of research bodies hold Open Days. Visitors are welcomed to the laboratories to see what is going on. Amongst others, the National Physical Laboratory is "open" to-day, the British Coal Utilisation Research Association's laboratories on June 7th, and the British Non-Ferrous Metals Association laboratories on May 24th to 27th. The views of research workers about Open Days are, no doubt, mixed; many of them will certainly regard those days as a nuisance. For the holding of an Open Day necessarily causes an interruption of work. Associations vary in their methods. Some, like the Road Research Laboratory, which held two Open Days last week, go to a great deal of trouble to put on special demonstrations; others do little more than tidy up. But, however much or

little is done to make the work of the laboratory more understandable to visitors, there is inevitably an interruption of the ordinary routine. One cannot effectively set up an apparatus, still less take a series of readings, under the fire of questions from numerous visitors ! Moreover, particularly when special demonstrations are arranged or equipment not regularly in use is put on view, the interruption to work extends over a period much longer than the actual hours of the Open Days. Several days may be lost to active research in tidying laboratories up, rearranging, setting up equipment, drafting notices and so on ; and several more in getting back to normal. Is it all worth while ?

Some research bodies never hold Open Days. They must forgive us for believing them mistaken. For, quite apart from the pleasure and the instruction conferred upon visitors to the establishment, there are advantages for a research laboratory, too, if upon one or two days in the year it is thrown open to visitors. A minor advantage is that it makes it necessary to " tidy up." It is always easier to find time to erect equipment than to dismantle it ; so that unless some particular occasion is set aside for the purpose there is in a laboratory—or for that matter in a works, an office and even the home—a tendency for the disused to collect and clutter up the place. But there is a more profound and less obvious advantage. Researches in engineering are undertaken with definite objects in view. But often after an apparently straightforward research has been begun, it is found that further progress cannot be made without finding a solution to some subsidiary problem ; and for the solution of that subsidiary problem still another side issue may be raised. It is, in fact, not at all difficult for a research worker to get himself so bogged down in side issues that the original object of his research becomes almost forgotten ! In addition many a research worker, we suspect, after labouring hard and long to solve some relatively minor problem, has found on getting an answer that it gives not merely no assistance in solving the major one but that had he thought hard enough to begin with he could have seen that it could give no such assistance. It is, in fact, possible to concentrate too hard ; and good at times to have that concentration broken. Each time an Open Day comes round a research worker does so have his concentration broken. For he must prepare himself to describe what he is doing to outsiders and answer their questions. Most of the people, of course, who pay the laboratory a visit will not have the specialised knowledge necessary seriously to question the value of his work ; and even those who have are very unlikely directly to attack him on the point. Yet the interruption and the need to describe what he is doing will cause him to look for a little while at his work " in the round " and in its relation to everyday problems and everyday practice. It is no bad thing for a research worker to have to ask himself once in a while " Why am I doing this work ? What purpose will it serve when I have the answers ? "

But the prime object of Open Days, no doubt, is to bring research workers and the more practical people whose problems they aim to solve directly into contact. The value of that contact can hardly be exaggerated. It would, for example, be of very little value for the Road Research Laboratory, one of whose Open Days we attended last week, to specify an optimum water content for a concrete mix, if it failed to recognise that in the field there will always be a tendency for it to be exceeded. Man is perennially seeking the easier path and a wetter mix is more easily workable. Research must be accompanied by the development of machines and devices that will permit its discoveries to be applied in practice. But unfortunately something else besides development is needed. It is, in fact, rather a saddening experience to visit the Road Research Laboratory. So much is being done ; so much has been developed into really practically useful knowledge ; so much is now known about soils, soil stabilisation, road design and road surfacing. Yet so little is being applied. No criticism either of the Laboratory or of highway engineers is here implied. There is plenty of evidence of the high repute in which the work of the Laboratory is held. What holds back application is the refusal of successive Governments since the war to expend enough money on road construction and reconstruction. Nor is there any lack of liveliness in that other division of the Laboratory which is concerned with traffic and safety. Indeed, particularly since the war, that division might justly claim the credit for putting some factual and scientific sense into discussions of safety on the roads. For instead of blaming the immoral recklessness of road users for the numbers of accidents on the roads it has patiently set about discovering not how people ought to behave on the roads but how they actually do behave on them and how, in the light of that behaviour, roads and vehicles can be made safer—a far more profitable approach which would pay even greater dividends if more money was spent on the roads.

Literature

Spontaneous Ignition of Liquid Fuels. By B. P. MULLINS. London : Butterworths Scientific Publications, 88, Kingsway, W.C.2. Price 20s.

IN this book, sponsored by the Combustion Panel of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organisation, Dr. Mullins has set out to summarise and review the present state of knowledge of the spontaneous ignition properties. The review covers both experimental procedures and the systematic collection of values for ignition temperatures. Furthermore, with the aid of 347 references to literature covering the last fifty years, the book provides a valuable and rapid guide for the engineer or combustion research worker wishing to study techniques of measuring spontaneous ignition temperatures or the application of the data to practical problems. The author has found a commendably clear path through the plethora of original data. This he has done by admitting from the outset that for a given mixture ignition temperature is not a sufficient description unless the delay period is known and specified. A brief summary of theoretical considerations is given introducing the Arrhenius concept of activation energy, also thermal and chain reaction processes. Separate chapters consider the heated crucible methods with and without flowing oxidant, also furnace and closed bomb methods. The method of adiabatic compression ignition, historically the first experimental method used for measurement of spontaneous ignition temperatures, is discussed in detail, as also is the classical work of H. B. Dixon, and the recent work of Dr. Mullins himself at the National Gas Turbine Establishment using a high-velocity flow system capable of measuring short delays over ranges of temperature and pressure pertinent to gas turbine problems. Numerical values of spontaneous ignition temperatures are given for some 400 substances, together with details of method, delay and oxidant. The effect of additives and variations of physical conditions on the delay are briefly discussed with adequate reference to key review papers in the literature.

The application of the data in problems of combustion engineering is considered with reference to fire hazards, and problems of piston, turbine and rocket motors. The relevance of the application to problems of " knock " and pre-ignition in engines is beyond question (motored engine studies form a convenient bridge in this field). In the gas turbine, problems of reheat are clearly dependent on spontaneous ignition considerations. In the analysis of primary zone conditions, or combustion in the wake of bluff bodies, other powerful methods of analysis are now being developed, and the significance of spontaneous ignition data in these regions is open to question.

The presentation is clear, particularly in reference to original work. The book satisfies a real need of combustion engineers and research workers in the field.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

COAL FOR INDUSTRY

SIR,—At the risk of referring to statistics, which, as you say, are becoming monotonous, I would refer to your wholly admirable leading article of April 29th, which very rightly emphasises, once again, an altogether sorry state of affairs.

The Chancellor of the Exchequer, in his Budget Speech, outlined the necessity for keeping down the volume and cost of imports to the bare minimum. Coal is to remain the basic need of most British industries for several decades, and if industrial production is to be maintained, let alone increased, the coal situation as it exists to-day must be accepted by all industrialists. The fact is that production is virtually static and is likely to remain so for some years to come, although it is appreciated that the National Coal Board has to face very considerable domestic difficulties. This fact must be faced, and the only way to ease the position is to strive for the utmost economy in industry. Considerable savings in coal consumption can very often be achieved at a comparatively low capital expenditure, apart from schemes on a more grandiose scale.

It should be emphasised that Government loans on very satisfactory terms have now become available to industrialists who wish to improve the efficiencies of their plants, so as to achieve reductions in fuel consumption. In this connection, the services offered by the National Industrial Fuel Efficiency Service, in carrying out surveys of works with this object in view are of inestimable value.

In conclusion, I would outline a few of the methods which can be employed to improve the position.

(1) By the installation of modern mechanical firing equipment, the lowest grades of coal can be burned in industrial shell type boilers without

derating and without the emission of smoke.

(2) There is still vast scope for extending the use of back-pressure generating plant which is often capable of showing at least double the thermal efficiency obtained with any public generating station. This statement is borne out in the Industrial Steam Survey which was carried out some months ago, and recent reports state that the present position is now being studied by the Minister of Fuel and Power in conjunction with his Fuel Efficiency Advisory Committee, so that it may be determined how the advantages of this system of generation can best be realised.

(3) There is also considerable scope for utilising the waste heat of internal combustion engine plants, which is often recoverable both from the exhaust systems and from the cooling jackets of such engines.

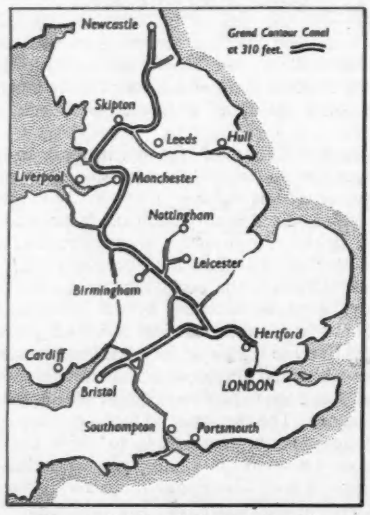
These suggestions must be balanced by the realisation of the importance of using heat efficiently in a factory and such matters as combustion efficiency and the installation of well-designed boiler plant may well be neutralised if the heat produced is thrown away needlessly by inefficient space heating or bad heat utilisation in some process.

The subject of the insulation of buildings is an important factor, but this is often ignored by architects and others.

Hove, 3, Sussex, April 29th. JOHN FOX, M.I.Mech.E., F.Inst.F.

INLAND WATERWAYS

SIR,—I was interested to see your editorial reference on April 22nd to the Grand Contour Canal and agree that plural functions, navigation and water grid are an essential basis of the project. The water grid idea is topical. The Grand Contour Canal, by following the outcrop line between the low claylands and the hard-strata uplands (as the old canals often did) would be able to maintain a uniform level of 310ft above sea level, and by suitable means this waterway of 1500 square feet sectional area could



Proposed "Grand Contour Canal"

discharge up to 2000 cusecs. As a water grid it would draw from hill streams and supply water-short areas all along its line.

My case then is: a Grid Commission regulating water regionally by trading in bulk, yes. The undertakings could buy as free agents to supplement local sources. Nationalisation, no; it is clumsy and of no assistance to grid operation.

As for water companies, so much out of favour, this commercial form of undertaking is very suitable for ground water recharge schemes, auxiliary to the grid. The Grand Contour Canal itself will be promoted by a free enterprise company so that consideration for the water grid use can be arranged without difficulty.

Slough, April 30th. H. POWNALL

German Industries Fair, Hanover

No. II—(*Continued from page 673, May 13*)

WE continue in what follows our descriptions of some of the more interesting exhibits which were to be seen at the recent German Industries Fair held in Hanover.

MANNESMANN-MEER A.G.

In the pavilion of the firm of Mannesmann-Meer A.G., of München-Gladbach, there was displayed a steam engine plant embodying several new ideas. It was shown producing alternating current for the Fair network, and at the same time making ice blocks by using the exhaust steam in a refrigerator. The steam was raised in a new type of U-tube boiler, designed under the patents of Dr. Schöll by the firm of M. Streicher, of Stuttgart-Bad Cannstatt. The working pressure was 32 atmospheres and 450 deg. Cent. and the capacity of the boiler was about 1000 kg of steam per hour. It was gas fired. The vertical enclosed type Meer steam engine, already described in our pages, has a designed output of about 320 h.p. at a speed of 750 r.p.m. It is arranged for double expansion and has two high-pressure and two low-pressure cylinders working at 32 atmospheres and 6 atmospheres respectively. It is interesting to note that by adopting a special construction of the cylinder, pistons, and piston rings it is now possible to run the engine continuously without oil for cylinder lubrication. This gives a completely oil-free exhaust and enables steam from such an engine to be safely employed in food processing and textile processes where heating is required.

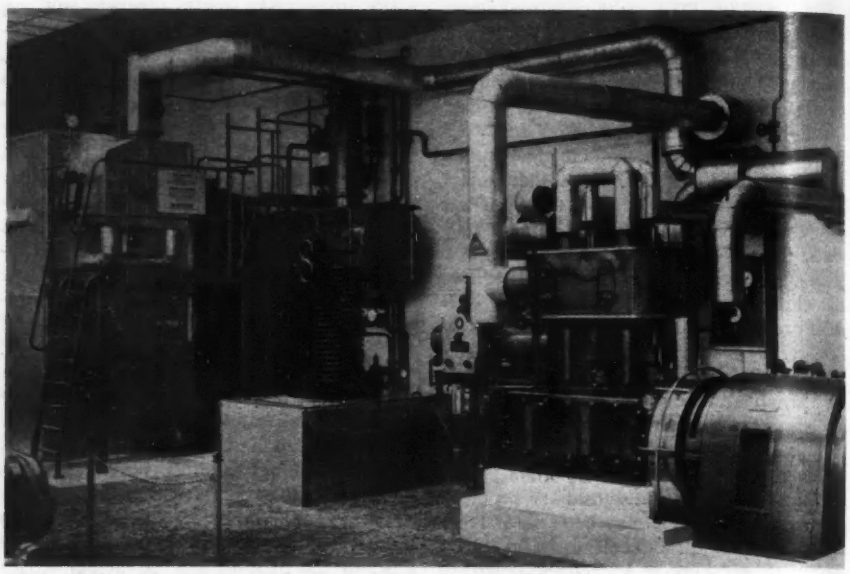


Fig. 7—Boiler, steam engine and absorption refrigerating plant—Mannesmann-Meer A.G.

The steam is passed through an intermediate superheater before it enters the high-pressure cylinder. The engine, as shown in our illustration (Fig. 7) is coupled direct to an alternator constructed by the Schorch Werke A.G., of Rheydt, and this firm also supplied the switchgear and synchronising gear. The exhaust steam cannot all be used in this Fair plant and part of it passes to atmosphere, but another part passes into the ammonia absorption refrigerating plant shown between the engine and the boiler, which was designed and supplied by the C. Senssenbrenner G.m.b.H., of Düsseldorf-Oberkassel It is designed to give a refrigerating capacity of about 400,000 kilocalories per hour.

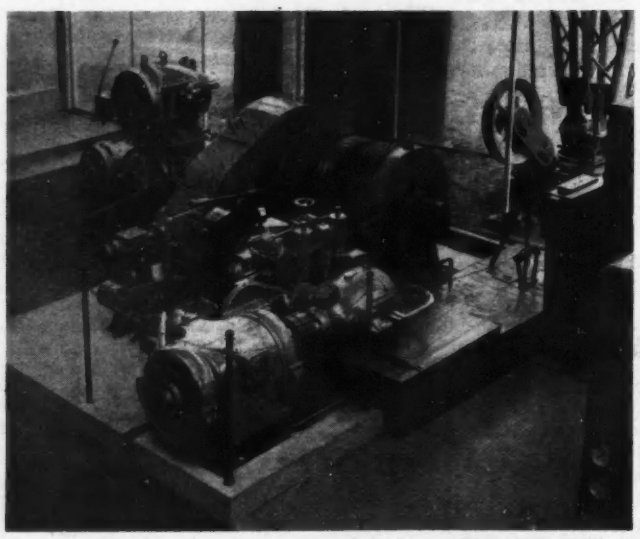


Fig. 8—All-hydraulic crane drive—Mannesmann-Meer A.G.

In the same pavilion there was also demon-

strated a new kind of crane control which is hydraulic throughout for the luffing, slewing and hoisting motions. The principle employed is that of the Thoma oil-hydraulic axial piston. It is employed alike in the motor-driven pump and the power drive unit. The general arrangement of the plant will be clearly seen from Fig. 8. In the foreground will be seen the a.c. motor driving the pump unit, while immediately in front of the winch barrel is the power drive for the various crane motions. By means of an outside jib the operation of the crane mechanism was demonstrated, and was shown to be remarkably smooth and quick, for all the motions. This new principle has been worked out by the Mannesmann-Meer A.G. in collaboration with the Travaux Metalliques de Boom S.A., of Belgium, and it will be employed for the first time in the construction of six harbour cranes for the "Hesse-Natie" in the harbour of Antwerp. The firm of Mannesmann-Meer A.G. is represented in Great Britain by D.M.M. (Machinery), Ltd., of 66, Victoria Street, London, S.W.1.

Kampnagel Aktiengesellschaft

On its stand at the main entrance to the Fair the firm of Kampnagel A.G., of 26, Jarrestrasse, Hamburg, 39, showed a large foundry crane which we illustrate in Fig. 9 herewith. It has been designed and built for the converter house of a large German steel works operating on the Thoma system. The capacity of the crane is such that it can lift and handle a 50-ton ladle filled with molten steel. An auxiliary lifting hook of 15 tons capacity is utilised for the tipping of the ladle, and pouring into the moulds. The crane is also built for the charging of the converter with liquid metal or with other charging material, such as scrap in solid form. For that purpose a second auxiliary hook is provided, which, like the other, has a lifting capacity of 15 tons.

The crane has a span of 18·5m and a lifting speed of 6·1m per minute, with a 50-ton load. The lifting speed can be increased while under load to a speed of 16·7m per minute when lifting loads of 15 tons. The crane crab is designed to travel at a speed of 40m per minute, and the crane itself at a speed of 100m per minute. The 15-ton auxiliary lifting blocks also have a lifting speed of 16·7m per minute.

As will be seen from our illustration, the construction of the crane follows the modern box form. All runways are covered with light lattice work and contactor connections are provided at the top of the crane girders. There are four motors for driving the crane, each of which drives one wheel through enclosed gearing.

The form of the converter shop in which the crane is to be installed has necessitated the adoption of a somewhat low design, as can be seen from Fig. 9. The driving cab, which gives a good view of the working field, is built within the space just below a main girder. All the electrical equipment was designed and built by the Siemens-Schuckert Werke, and the switchgear and fuse boxes are all contained in an enclosed box with dust-proof doors. When starting all four motors are employed in order to bring the crane up to its maximum speed as soon as possible, but when that speed has been attained the automatic relays in the switchgear cut out two of the motors, leaving two motors only in action.

Krupp-Ardelt G.m.b.H.

An exhibit which dominated the stand of Krupp-Ardelt G.m.b.H., of Wilhelmshaven, was the 35-ton "Autocrane" which has been designed and built for the repair and maintenance service of the Rheinsche A.G. für Braunkohlenbergbau. It is believed to be the largest crane to be equipped with heavy tyres for road transport. The wagon frame is of saddle form, with the crane mast at the rear, as clearly shown in Fig. 11. The centre part of the frame is designed to accommodate the rope winch barrels for the hoisting and manœuvring motions of the crane, while forward are the side switch-boxes for the A.E.G. electrical equipment and beyond that the two raised oil fuel tanks for the 210 h.p. driving engine, which is of Krupp two stroke design. Fig. 10 shows the upper portion of the mast with the inclined jib member, and the travelling operating platform which can follow the load when hoisting and lowering or can be moved independently as may be required.

The crane is designed to lift and traverse a 35-ton load at a 3m radius, or 30 tons at a radius of 6m, without external support. A load of 12·5 tons can be lifted and carried at a 14m radius. The rear axle as well as the forward axle is power driven, and the rear axle is carried on four Firestone "Giant" tyres, having a diameter of 2·25m. The outer wheels are connected to the inner wheels by means of a strong tubular flange, and a small hand crane allows the outer wheels to be taken off when it is desired to prepare the crane for road transport. The crane mast is in two parts, which telescope one into the other, so that the mast can be lengthened or shortened for various duties. It is designed to lift, along with the movable jib, loads up to a maximum height of 20m, the height of a seven-storey building.

The lifting of the mast and the other crane movements are fully hydraulic and the mast traversing equipment is spindle driven. The generator on the 210 h.p. engine provides current for all the electrical equipment and the hydraulic pumps.

When preparing for road transport the jib is folded in and the mast shortened until it can be lowered on to the frame of the wagon. In that position the height of the crane is only 3·4m. When the two outside rear wheels have been taken off the width of the crane is only 3·8m and it can be driven at a road speed of 50km per hour, which compares with a speed of 4km per hour when carrying a load. The crane was delivered from the Wilhelmshaven works to the Hanover Fair ground by road. During

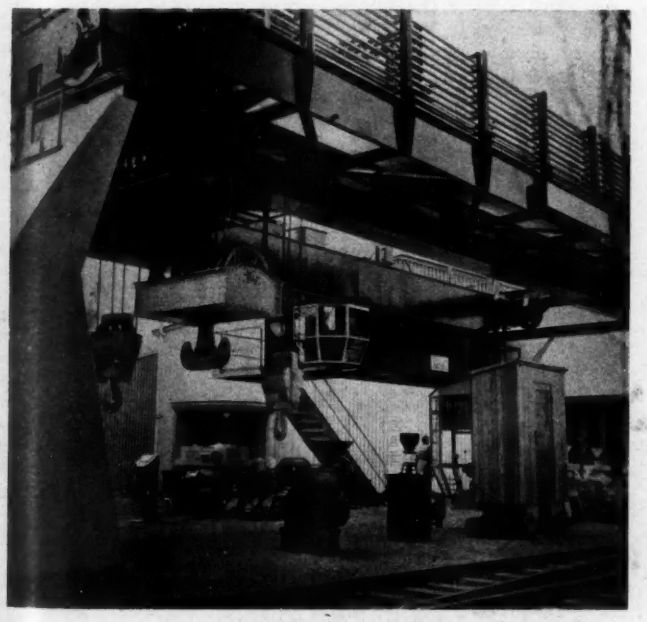


Fig. 9—50-ton crane for converter operating—Kampnagel

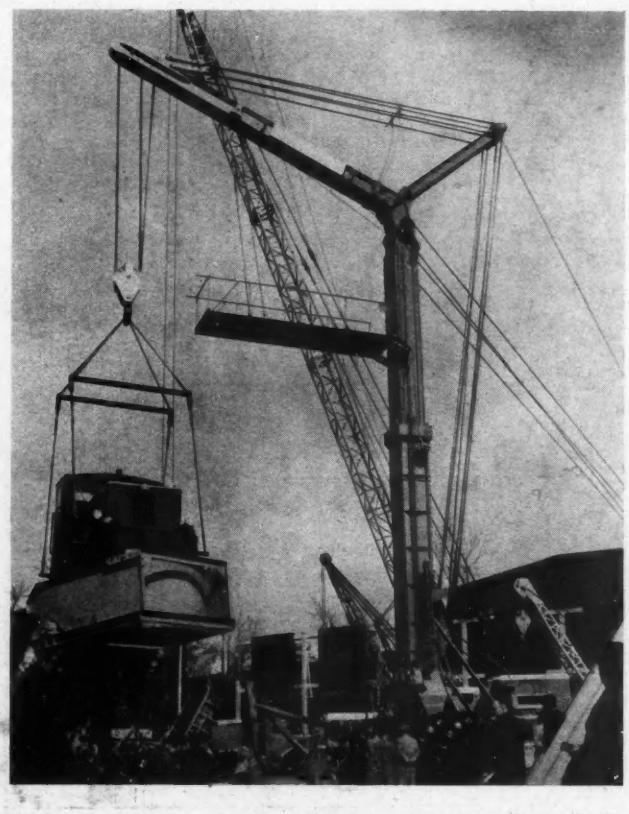


Fig. 10—35-ton "Autocrane" showing jib and operating platform—Krupp-Ardelt

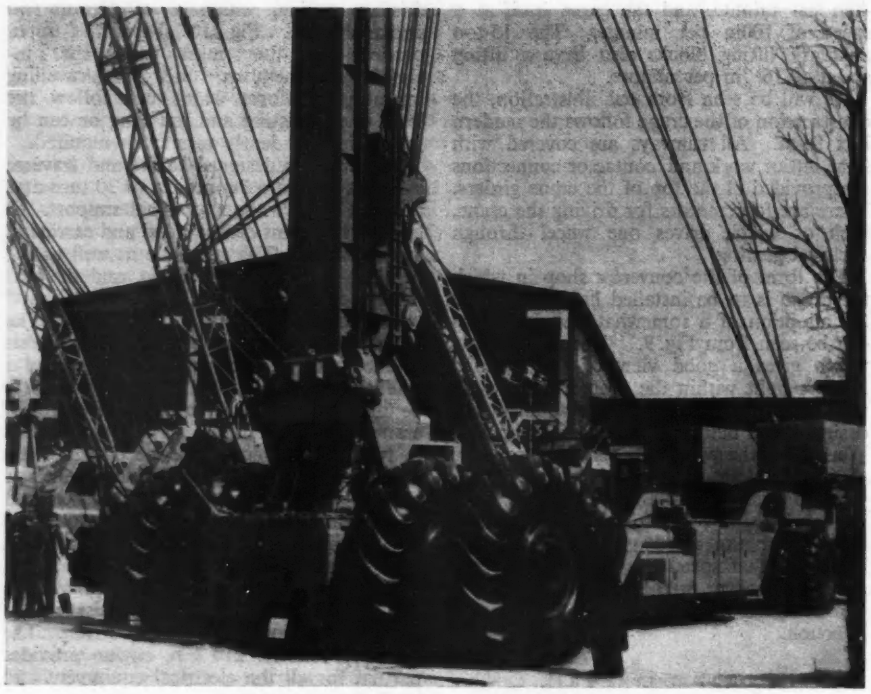


Fig. 11—35-ton "Autocrane" showing wagon and lower part of mast—Krupp-Ardelt

the Fair power was taken from the Fair network to demonstrate the crane without running the main engine, and a shunting locomotive was lifted and lowered.

Maschinenfabrik Buckau R. Wolf A.G.

Alongside one of its standard "locomobiles" and an example of its steam piston turbine, the Maschinenfabrik Buckau R. Wolf Aktiengesellschaft, of Grevenbroich-Neuss, showed a new double-pressure steam boiler which has been designed to fill the gap between the large Buckau-Sulzer single-tube, high-pressure boiler and other water-tube boilers of large capacity, and smaller boilers used in industrial works. The boiler is designed according to the principle of Dr.-Ing. Hartmann, and is small in dimensions. It is quickly started up and has a good efficiency. It is shown in Fig. 12.

The primary boiler is a simple form of water-tube boiler of horizontal design with a series of tubes giving an automatic circulation. As the tube system has a small water content, heating takes place quickly. Various kinds of automatic firing with solid fuel gas or oil can be used. By means of a heat exchanger under the upper steam drum the heat of the primary steam is transmitted to the water in the secondary boiler. The latter consists of a simple drum which is dimensioned to fulfil the steam duty required. The pressure in the primary system is somewhat higher than that in the secondary system. The secondary boiler drum has a large water capacity and saturated steam can be produced freely at the required working pressure. The steam leaves the water easily and there is no frothing. The saturated steam is then delivered to a superheater, should high temperature steam be required for the power plant. With a feed-water heater heated with the gases from the primary boiler, boiler efficiencies from 80 up to 90 per cent can be attained. The type of boiler illustrated is built in twelve sizes with steam capacities from 1 ton up to 12·5 tons per hour. As will be seen from the photograph, no expensive boiler foundations are required.

Henschel und Sohn G.m.b.H.

Among the many exhibits on the stand of Henschel und Sohn G.m.b.H., of Kassel, an unusual exhibit was the bulldozer shown in Fig. 13, which is not a track machine but is mounted on heavy-duty Firestone-tyred wheels. By this means quicker movement is obtained in all directions, which is facilitated by arranging that the wheels on one side can turn in one direction and those on the other side in the reverse direction. The power unit is a 200 h.p., six-cylinder Henschel diesel engine, which drives two high-pressure hydraulic pumps working on the Thoma principle, which provides an infinitely variable speed of the vehicle from 2km up to 30km per hour. The 4·5m wide front blade can be lifted and lowered by two oil-hydraulic cylinders and it can also be slanted to either side. Between the wheels will be seen the small crane, also hydraulically operated, which has been provided for moving obstacles, for carrying railway track and for other similar uses.

Another exhibit was an example of the company's series of diesel-hydraulic locomotives, suitable for express services and for goods train and shunting operations. The example on view at Hanover is shown in Fig. 14. It has four driving axles on two bogies. Two speed ranges are provided, the first from 0 to 45km per hour, and the second from 0 to 90km per hour. The 875 h.p. Henschel diesel engine drives a three-stage Voith turbo-transmission consisting of a hydraulic converter and two hydraulic clutches. The locomotive is built for 1435mm standard gauge and has 1m diameter driving wheels, the wheel base of the bogie is 2·8m and the distance between the pivots 6·1m. The total wheel base is 8·9m and the length over the buffers 14·3m. The maximum height is 4·1m and the maximum width 3·15m. The tractive effort corresponding to a speed range of 45km to 90km per hour is 18,000kg to 13,000kg. The weight of the locomotive in working order is 60 tons.

The cooling system has a hydrostatically driven fan and the speed is set according to the temperature of the cooling water by an automatic control device. The engine and superstructures are all mounted on the

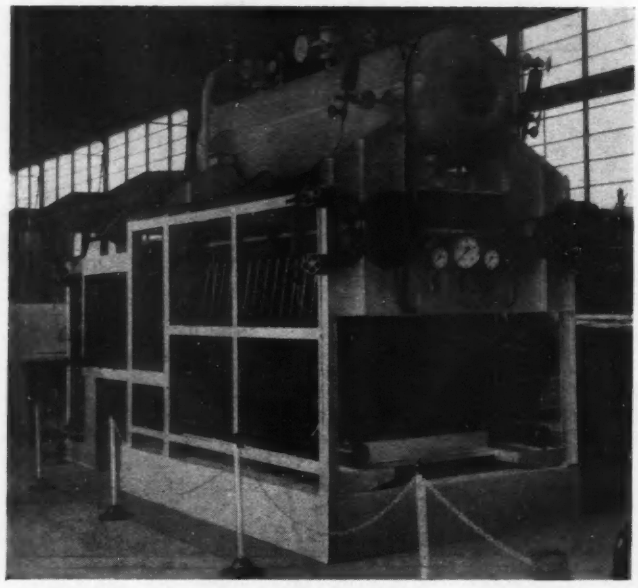


Fig. 12—Double-pressure steam boiler—Buckau-Wolf

Fig. 13—Bulldozer on tyred wheels with crane—Henschel

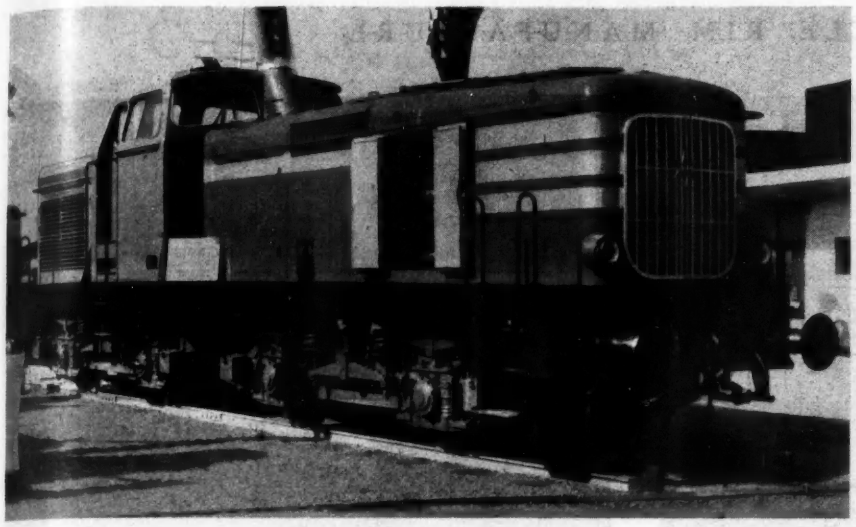


Fig. 14—Diesel-hydraulic two-bogie locomotive—Henschel

Silentbloc system and are sound insulated. Roller bearings are used in the wheels and the pivots are laterally cushioned to give smooth running at high speeds and on banked tracks and curves.

Soest-Ferrum Apparatebau G.m.b.H.

An interesting machine for the ceramic industry was shown for the first time on the stand of the Soest-Ferrum Apparatebau G.m.b.H., of Düsseldorf-Oberkassel Hansa Allee 159. It is a vacuum press combined with a vibrating sieve, which is designed to give a completely homogeneous structure to the extruded mass of clay, such as is used for the manufacture of high-grade insulators for the electrical industry and for similar porcelain and clay articles.

Research on this new method of freeing an extruded clay mass from all kinds of cracks and fissures, has now been going on for some eighteen months, and the new kind of press shown in the accompanying illustration (Fig. 15) is now, we learn, in production. The clay to be worked and pressed is delivered to the machine by means of a conveyor belt which will be seen at the left-hand side. The material is fed forward by an internal worm, and passes through the vacuum chamber to the discharge chamber and nozzle. The sieve is mounted at the inner end of the discharge chamber. The vibrating motion is supplied to the outer end of the machine by spring members which will be seen on the right-hand side of the illustration.

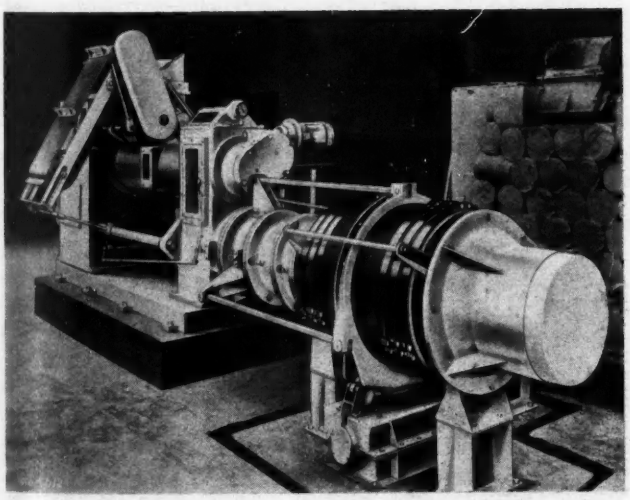


Fig. 15—Vacuum press with vibrating sieve—Soest-Ferrum

Tests which have been made on clay extruded from this new type of press, and compared with samples from ordinary pug mills, with and without air excluders, are claimed to show a much closer texture and density, and freezing and microscopic tests are stated to have revealed an absence of cracks and fissures. The quality of the extruded mass is said to be greatly improved, and the capacity of the machine is also increased when a vibrating sieve attachment is fitted. A normal press with a worm diameter of 250mm is usually designed to extrude masses of 150mm maximum diameter ; but masses up to 350mm diameter can be worked when the sieve is fitted without losing quality.

Henschel Maschinenbau G.m.b.H.

The engine building section of the Henschel firm has been transferred to new and modern works in Hamburg, where land and marine engines, two-stroke and four-stroke auxiliary engines, steam turbines, presses and other machines are built. An example of this company's work is shown in Fig. 16. It is the engine installed in the locomotive shown in Fig. 14. It has fourteen cylinders arranged in V form and a designed output of 875 h.p. at 1250 r.p.m. An engine with twelve cylinders similarly arranged and with an output of 750 h.p. at 1250 r.p.m. can also be used in that locomotive. These engines are built under S.E.M.T.-Pielstick licence by the Hamburg firm. They operate on the four-stroke principle with a precombustion chamber, and an exhaust turbo-charger. The welded, all-steel crankshaft housings have no anchoring rods and extend upwards to the upper third of the cylinder liners, which are inserted in the water jackets. By this means special rigidity is obtained. The driving gear is easily accessible from both sides of the locomotive. Considerable use is made of standardised parts in the assembly of these engines. The bore of the cylinder in the engine we illustrate in Fig. 16 is 175mm and the stroke 210mm. The speed of 1250 r.p.m. corresponds to a mean piston speed of 8·75m per second, and the fuel consumption works out to 168 grammes per horse-power-hour. The mean effective pressure is 5·95kg per square centimetre without and 8·9kg per square centimetre with supercharging. The cylinder output is 42 e.h.p. without and 62 e.h.p. with supercharging, and the weight per effective horsepower 8·8kg without and 6·7kg with supercharging. The design is such that the engine can carry a 10 per cent overload for one hour.

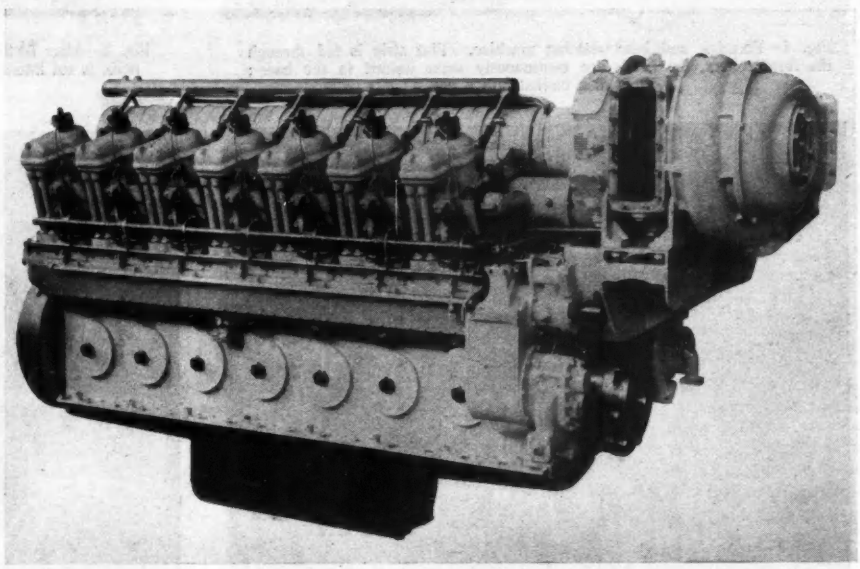


Fig. 16—Fourteen-cylinder, four-stroke, 875 h.p. diesel engine with supercharging—Henschel

(To be continued)

"Brightray" Series of Electrical Resistance Materials.—A leaflet, issued by Henry Wiggin and Co., Ltd., Thames House, Millbank, Westminster, S.W.1, describes the "Brightray" series of electrical resistance materials, including a recent addition to the range—"Brightway H," which is suitable for furnace elements operating in the range 1100–1250 deg. Cent.

CYCLE RIM MANUFACTURE

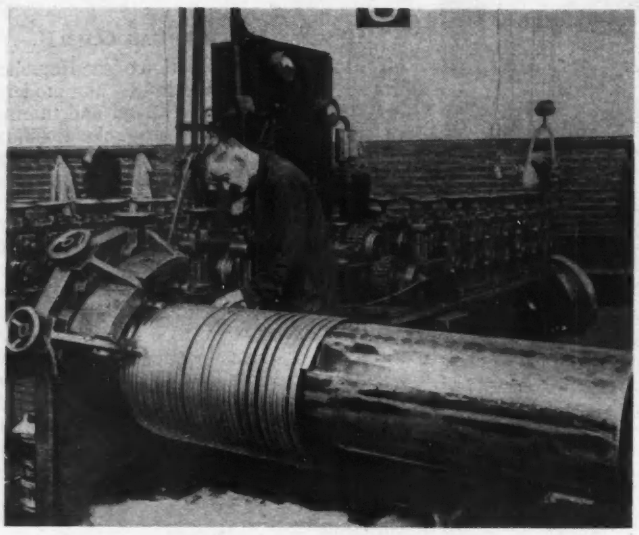
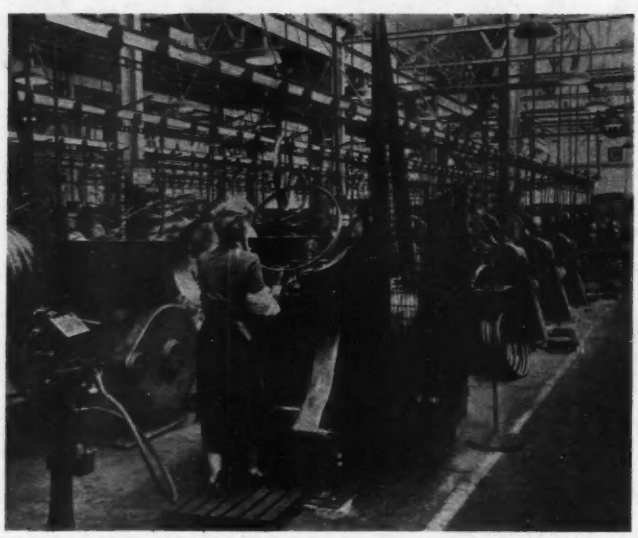
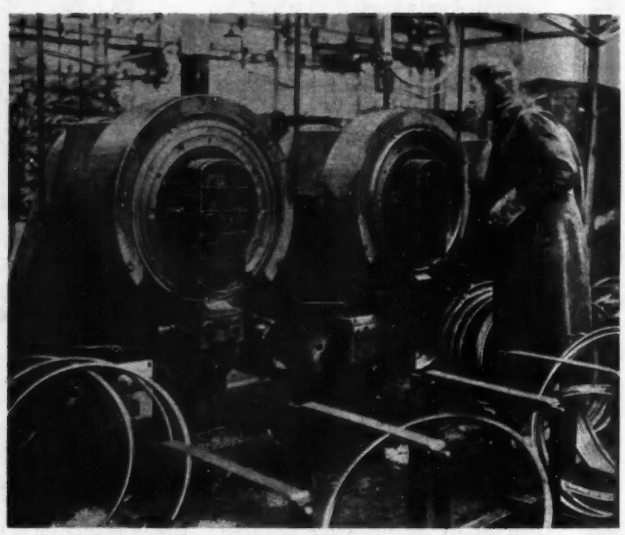


Fig. 1—Forming and bead welding machine. Flat strip is fed through the form rollers, the beads are continuously seam welded to the base; it is then circled into a coil

Fig. 2—After further forming and ironing operations the strip in a close helix is cut into single rim lengths (foreground) and butt welded (right)





Figs. 3 and 4—Pneumatic hand chippers (left foreground) and polishing machines complete the dressing of the joint. A rim is about to be lowered over the blocks of the expanding machine. A manually-operated spoke hole piercing machine can be seen in far background, whilst the automatic machines are shown in Fig. 4

Fig. 5—New design "enclosed" polishing machines

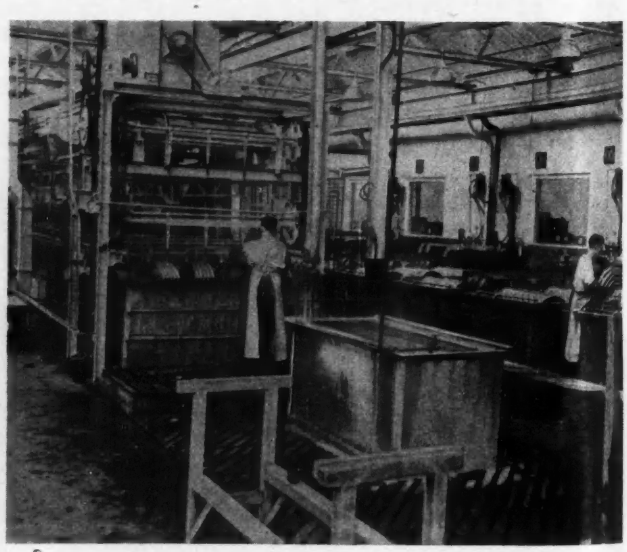


Fig. 6—Automatic cleaning unit and nickel-plating vats (right)

Cycle Rim Manufacture

This article discusses the production of a bicycle wheel rim. The rim is profiled in continuous strip and coiled, from which each coil is subsequently cut and butt welded to form a rim. After rim piercing operations the wheel is cleaned and plated. Mention is also made of a new system in which the rim is butt welded before the profiling sequences.

THE Dunlop Rim and Wheel Company, Ltd., at Coventry, first commenced making rims for bicycle wheels in 1901, following the advent of the pneumatic tyre. It has since become the largest producer in the world of this bicycle component, and we give an account here following a recent visit to the Coventry works of the production of a typical rim.

Many different kinds of rim are produced, the bulk being made from a good quality, low-carbon mild steel, the specification of which is rigidly controlled at the works laboratory. Smaller quantities are produced from stainless steel, and for special racing rims light alloy sections are used. Although the different rim sections and materials introduce slight variations in manufacturing technique, the production sequence can well be illustrated here in connection with the "wired-on" type rim shown in diagram *b*, Fig. 7, which form about 60 per cent of the total production.

The steel strip is purchased in coils weighing approximately 4½ cwt to 5 cwt, and is fed from the coil into a machine known as a forming and bead welding machine, at a speed of 20ft per minute—shown in Fig. 1. These machines mount seven pairs of form rollers driven by a train of gears, which, as the diagram indicates, progressively form the two beads of the rim in preparation for welding. The welding electrodes on each machine are also in line, there being one for each bead, which produce a continuous seam weld of the beads to the base of the rim. After welding, the strip is either water or air-cooled and passes to circling rollers mounted at the end of the machine. As the strip leaves the circling attachment it is loosely coiled on to a drum. For convenience in handling during the subsequent operations on the ironing and sawing machines, the machine is stopped when there are approximately forty rims in the coil, which is then sawn through and the machine restarted.

The ironing machine, through which the coils of sectioned strip are then passed, is basically similar to the forming and bead welding machines, but has no welding attachments. These machines simply continue the development of the rim to its final form, as shown in diagram *b*. As the rims pass through the machine, the edges of the strip at the weld are chamfered off to prevent any chafing of the tube and tyre. Although the machines have seven pairs of rollers the section is fully formed by the time it has passed the fourth pair. On the recircling attachment of the machine, the final diameter of the rim is determined and the rims are consequently passed on the drum in the form of a close helix, slightly larger in diameter than the finished rim to compensate for the material burnt away and upset during the butt welding of the joint. From the ironing machine the coils are transferred to small fly saws, where by means of a banding tape and scriber attachment the length of each rim is marked off and then progressively cut off from the coil. This can be seen in our illustration (Fig. 2).

The forming, ironing and sawing machines are all grouped at one end of the mill to serve parallel production lines arranged to conclude the fabrication of a particular range of rims. Each of these lines is equipped with a continuous overhead conveyor on which the rims can be hooked and passed to the various operations necessary to complete the rim. The first operation on these lines is the butt welding of the joint. Because of the thin rim section and the small butting area, special precautions are taken to ensure the ends of the rim are correctly lined up and seated during the butt welding operation.

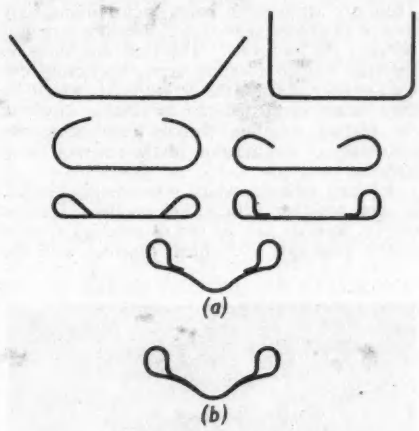
At the next station the flash on the inside of the joint is removed with a pneumatic chipper having a formed chisel—shown in the foreground of Fig. 3. The next operation is expanding. The joint of the rim is located into a loading claw on the machine and then lowered over circular formed blocks which travel outwards and stretch the rim to a determined diameter, thereby making the rim truly circular and to the correct circumferential size to suit the tyre. Each rim is then checked by a measuring band to ensure it is the correct size, a tolerance of only 0·050in in circumference being allowed. Three further operations of grinding and polishing the joint to remove all welding marks complete the dressing of the joint. Figs. 2 and 3 show all these operations sequentially.

The rims next pass on to automatic machines to pierce the holes for the spokes. Here, the rim is clamped into a quick-acting chuck on the machine which indexes past the punches, two holes being pierced simultaneously, and at the end of the cycle the machine stops (Fig. 4). For small quantities the punch is hydraulically operated, but the rim is indexed manually, each hole being located from the preceding hole by contacting a peg on the bolster. Holes are dispersed equally each side of the joint and are staggered alternately about the centre of the rim to accommodate the angle of the spokes from the hub. The final operation on the rim is the piercing of the valve hole, which is carried out on a small power press. Each rim is then visually inspected for defects.

Polishing

Rims have then to be polished in preparation for plating, which is done in a separate shop at the end of the rim-making department. At one time this operation was the dirtiest and noisiest one in the whole production. It was carried out on open polishing machines, shown in Fig. 9, and in spite of the elaborate system of hoods and extraction ducts, the dust concentration in the department was high, resulting in a high percentage of labour turnover. New design, fully enclosed machines have been developed by the company and very few of the old machines now remain; these are being rapidly replaced as the new machines become available. The new plant is shown in Fig. 5. Under the floor of the shop, with the new machines, there is a system of trenches linking each machine to main ducts leading into collectors situated outside the building into which all the lighter dust is extracted by powerful fans. The heavier particles of dust collect on the floor of the ducts which are large and can readily be cleaned out. By this method, the dust is kept out of the atmosphere of the shop.

The rims are loaded through the hinged lid of the machine and readily locate into formed rollers on a cradle inside the machine. When the lid is closed, the rim automatically makes contact with two calico mops, dressed with fine emery, each driven by 5 h.p. motors, with each mop polishing one-half of the rim, the cycle of the machine being controlled by a hydraulic system. The improved conditions of the department with the new type plant can be seen by comparing Figs. 5 and 9. After inspection the rims pass to the plating shop.



a) Section forming on bead welder.
(*b*) Final form on ironing machine.

Fig. 7—"Wired-on" cycle rim

Plating

An overhead conveyor transports the rims from the polishing shop to the plating department, which is situated in another building. The first operation covers the cleaning of the rim to remove all grease and dirt left on by the polishing. This is carried out on an automatic cleaning plant (Fig. 6), which comprises a long tank subdivided into six smaller tanks, which is traversed by an overhead conveyor with bars from which the rims are suspended. The sequence of the tanks through which the rims pass is: first electro-clean and second electro-clean;

Fig. 8—General view of flat-band production line

hot water swill ; cold water swill ; electro-acid etch, and cold water swill. The conveyor moves the rims along and lowers them into the first cleaning tank through which they travel slowly ; it then raises, pauses for a short time to allow the rims to drain and dips into the next tank, and so on, until the rims have passed through all the tanks in sequence. The time cycle for the movement and dwell of the conveyor is controlled by adjustable limit switches placed on the track of the conveyor chain. From the cleaning plant, the rims pass on to the nickel-plating vats. These are arranged in pairs, each holding sixty rims, with driving gear to carry the rims arranged between the two vats. The rims are hung on specially shaped rotating arms, projecting out across the vats from the centre drive, which, as they rotate, cause the rim to revolve slowly in the plating solution, thereby eliminating the possibility of any portion of the rim not being plated.

A Watts solution, which is constantly filtered, is used together with nickel anodes. Electric current to each pair of vats is supplied from a 4000A generator set, which, together with the

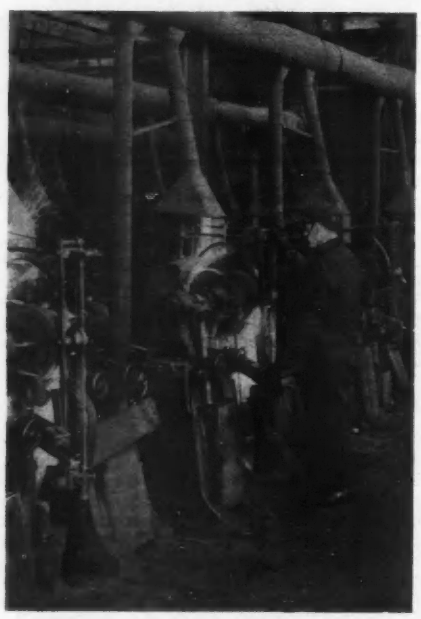


Fig. 9—Open design polishing machines (this method is now obsolescent)

control gear and the ancillary instrumentation, is housed in a separate building running directly alongside the plating shop, large windows being provided in the dividing wall between the two sections to give ready observation of the generators and instruments. The company referred to the particular problems encountered in plating due to the profile of the rim and explained that it always aims for a minimum deposit of 0·0004in on the brake faces of the rim, the most important region from a wearing point of view. The thickness of the plate on the other parts of the rim varies due to the shape. After nickel-plating, the rim which has a dull appearance is polished on machines similar to those we have described for the polishing operation before plating and are then taken into a section at the end of the building for chrome-plating. Here the rims are first cleaned by being suspended in a bath of weak cyanide solution, then swilled and passed to the chrome vats. In the chrome vats the rims are suspended singly from hook type hangers into the solution of chromic acid, locating symmetrically around circular antimonal lead anodes. A much higher current is required with this type of deposit—approximately 250A per rim. After plating, the rims are swilled in cold water. That being the final operation, the rims are removed by a stillage system to stores and laid flat in long rows and successive rows interlaced placed on top into stacks. Stacks of approximately 12ft high and very long can be formed by this method of interlaced layers without damage to the rims or plating.

The Single-Strip Process

Much interesting development work has been undertaken by the company in the last few years on a new fabrication system which is likely to supersede that described. It largely reverses the order of the production cycle in that the first operation is the cutting of a strip to a length to make one rim and butt welding it into a hoop before profiling. This system has many advantages, not the least being the ability to wheel the rim between all the stations on the line. The most important property of this method, however, is the greater degree of control it affords over each of the seven forming operations, which, it will be appreciated, are each undertaken on separate machines and a most compact line of working stations can be set up, as can be seen in Fig. 8. The machines in this line are the actual experimental ones on which the process has been developed and for some months production at a slightly higher rate has been achieved.

Railway Flood Repairs in the North-West

We have received from the London Midland Region of British Railways an account of flood repair works carried out since last autumn in Furness and West Cumberland. Not all the incidences are mentioned here. The abnormally wet weather experienced during the late summer of 1954 produced a series of minor slips and floodings, but on October 10th persistent downpour resulted in the Maryport and Carlisle line being flooded in sections of about 13 miles of its 28 miles length. Between Bullgill and Aspatria the water on the tracks was 4ft deep in places, and the River Ellen, the main source of the flood water, covered the surrounding countryside, diverting its main flow along the railway line with its even gradient and curvature. All traffic ceased from 11 a.m. on October 18th until 12.15 p.m. on October 19th, from which time single-line working was instituted up to 9 p.m. on the same day. When most of the flood had cleared the only obvious damage was loss of cess ballast over long distances, coupled with local places where the track itself had been seriously undermined by scour. Anticipating that slips would occur as embankments and cuttings dried out, a speed restriction of 30 m.p.h. was imposed. This was at a time when the existing speed limit of 60 m.p.h. for what was a class "C" line, was about to be raised to 70 m.p.h. and the line was to be reclassified as "B.1," so that diesel railcars could be introduced and used to the best advantage. On October 18th reports of slips commenced to come in and in a very short time twenty-four major incidents and innumerable minor ones less than 8 yards long were noted.

Meantime, flood and storm damage had been occurring at various points throughout the remainder of the Barroe district. Two culverts partially collapsed near Coniston and the River Derwent demolished a wing wall and scoured out the back of one abutment of bridge No. 33 between Cockermouth and Workington. November brought further slips, the largest being on the Whitehaven, Cleator and Egremont single line between Sellafield and Moor Row ; 216ft of a 25ft high embankment at Florence Pit signalbox settled 5ft, taking the track with it. Fifty-four wagons of ashes were unloaded and the line restored. A further settlement of 2ft occurred a few days later. About half a mile away at St. Thomas's Cross, underground water had weakened the cutting slope, which suddenly flowed across the track in a plastic mass, carrying saplings and bushes with it. This material was particularly hard to handle and there seemed to be a never-ending deposit. Some 700 tons was removed in the initial stages. The River Caldew at Cummersdale, near Carlisle, completely changed its course and rapid work with gabions was necessary to prevent further erosion. It severed an occupation roadway, cut an arc-shaped slice of land some 130ft long with a maximum width of 30ft from its old bank. The Barrow district has approximately 60 miles of coast line with its associated sea defence works and during the period tides, backed by gale force winds, breached the walls at several points.

The Whitehaven Junction Railway between Whitehaven and Workington, was built by George Stephenson and opened early in 1847. From records it is apparent that much difficulty was encountered. Between Parton and Harrington the line is carried on a stone-walled shelf below the cliffs, above which are situated both active and disused coal pits and brickworks, &c. Three main coal seams and several smaller ones appear at intervals with some of the workings extending under the sea. The geology at the site is extremely confused, being mainly sandstone and shale overlaid with boulder clay. The ground is badly faulted, including the fault at Micklam with a throw of 480ft.

At Micklam point the cliff is more like a steeply dished slope rising from rail level to a height of 200ft above the line, and, probably owing to its water-logged condition, it flows steadily downwards carrying the railway tracks with it, over the beach, which is stable. The length gang have for years regularly slued back and lifted the tracks to their proper curvature and level, but the movement towards the end of 1954 became so excessive that 95 lb F.B. rail was on numerous occasions buckled overnight and movement up to 5in per day was recorded. In addition, the cliff material encroached so much that it was no longer possible to slue the track back to the old alignment. Extensive remedial measures are now being considered, bore holes have already been sunk, drainage work undertaken and large quantities of spoil removed by mechanical plant. The movement has slowed down to not more than 1in per week.

Immediately south of Micklam Point the almost vertical cliffs are surmounted by steeply sloping overburden, again topped by pit workings and slag banks. The surface water, therefore, creates gullies in the overburden and cascades down the cliffs, bringing boulder clay as slurry over the tracks. In addition, the boulders themselves have to be dislodged by the length gang assisted as necessary, before they become a danger to passing traffic. The prolonged inclement weather produced so much slurry, coupled with such large slips, that material flowed across the tracks and traffic was delayed on several occasions.

It was decided that it was no longer practicable to cope with the situation without interfering with traffic, and complete possession of both lines was obtained for five week-ends last December and January. Explosives were used to assist the men in bringing down the overburden from the cliff top. This was loaded by mechanical plant, part of it going into wagons and part of it being discharged directly into the sea. It is estimated that some 8000 tons of spoil was removed. This work was only carried out as a temporary measure and arrangements are in hand to complete the work, and, at the same time, to improve the site conditions and facilities for disposing of debris, &c. This piece of railway always has to be closely watched and the ganger and sub-ganger of the length take it in turns to make a patrol at 3.45 a.m. each morning before the passage of the first train. During gales and high tides, the seas break right across the line to the cliff base and conditions for inspection in the dark are made extremely arduous. Undermining and abrasion of the walls supporting the track is severe and frequently results in cavities being formed. These, of course, have to receive immediate attention, and the gangers and their inspection reports are largely relied upon as a first warning. The last major washout which got out of hand occurred on December 30, 1951, when a large section of the wall disappeared, together with the material underlying the tracks, leaving the line suspended in the air. The line was closed to all traffic for seven days. For many years there has been a speed restriction of 20 m.p.h. by day and 10 m.p.h. by night, but on November 10, 1954, this was reduced to 5 m.p.h. day and night and it will remain until such time as the line is made more stable. It is hoped that permanent remedial measures will be commenced this summer so that previously permitted speeds may be restored, or even improved upon.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. VII—(*Concluded from page 675, May 13th*)

THE spring meetings were continued on the afternoon of Wednesday, April 6th, with Mr. Norman M. Hunter as chairman, with the presentation of the seventh and final paper, which was :—

THE CATHODIC PROTECTION OF SHIPS AGAINST SEA WATER CORROSION

By L. T. CARTER, B.Sc., R.C.N.C., and J. T. CRENNELL, M.A.

SUMMARY

When steel (e.g. a ship's hull) is immersed in sea water small galvanic currents flow from anodic parts of the surface of the metal causing corrosion. Cathodic protection is a means of stopping corrosion by suppressing these galvanic cells by a current passed to the hull from external anodes, thus making the whole immersed hull surface cathodic. Current may be obtained by using active anodes of a baser metal, or from an external supply through inert anodes. Various types of anodes for each method have been used, the most common being magnesium alloy and steel anodes respectively. The adequacy of cathodic protection in preventing corrosion is guaranteed if the electrical potential of the hull is maintained, by adjustment of the current, at about 0·8V to 0·9V negative to a standard silver electrode. Various applications of cathodic protection to ships and other structures are described, a particular example being that of ships laid up in reserve. The pros and cons of applying the process to special ships are examined. Reference is made to active problems in connection with cathodic protection including the effect on bottom paint and fouling, the application of cathodic protection in fresh water and to aluminium, and the use of zinc protectors.

DISCUSSION

Mr. W. A. D. Forbes: As a former chairman of the Admiralty corrosion committee it gives me pleasure that recent work of the committee should have resulted in the production of a paper of this value and importance. Over the past ten or twelve years this committee has done a very great deal of work on the maintenance of ships and has saved the Admiralty, and thus the general taxpayer, a great deal of money.

I think that it would benefit the shipping industry if the Institution gave more encouragement to papers on ship maintenance. In the past much attention has been paid to theoretical subjects and problems of resistance and propulsion, and I wonder whether the diversion of some of the money and effort to problems of ship maintenance might not give more worthwhile results for the shipping industry. We know that merchant ships will not reach supersonic speeds ; so what is the purpose of straining after the last fraction of a knot, which will be reached only in still water, and neglecting the fact that barnacles on the bottom may well reduce the speed by several knots and increase fuel consumption. Surely it is common sense to suggest that more attention paid to anti-fouling paints and corrosion problems might yield more valuable results for the shipping industry than, say, further studies of streamline flow.

The authors have shown conclusively that it is possible to protect from corrosion the hull of a laid-up ship or a floating dock almost indefinitely by methods which are simple, practical and cheap, and should prove of very great value to shipowners if ever again there should be a shipping slump. The methods are applicable to the fitting-out period, which has often been a fruitful source of trouble. On the question of zinc protectors, I doubt whether we shall have seen the last of these, if improved forms become available. Many shipyard workers regard these protectors as a troublesome nuisance, needing constant renewal, and feel pleased when they are found inactive and apparently require no attention. Since the purpose of these protectors is so little understood, it is hardly surprising that they so often receive unfair treatment. Not infrequently they are painted over and are given no chance to act, and often it is not realised that it is essential that the zincs should be in really good electrical contact with the steel hull.

Reference is made to stripping of the British Admiralty cold plastic anti-fouling paint having occurred during some panel trials in Canada. I have followed up the reference quoted and am a little surprised that the authors of this paper deemed this isolated occurrence, involving only one or two panels, worth recording. It would be unfortunate if it gave rise to misleading impressions concerning the Admiralty anti-fouling paint in current use. Wet sandblasting is mentioned, but we have to recognise that wet sandblasting is highly unpopular in our dockyards. I think it is considered to be a fad of the corrosion committee. The attitude to this problem in the U.S.A. is completely different. The economy of that country is built on the substitution of machines for manpower. For many years now wet sandblasting has been in universal use in U.S. Navy yards, and proved invaluable during the war. The equipment is also used by the Canadian and Australian Navies and apparently no difficulties arise from the silicosis angle. During the war in the Pacific the use of this equipment, together with hot plastic anti-fouling paint, enabled ships of the U.S. Navy to remain out of dock, and operationally available, for periods far in excess of anything known by our standards. Had the war in the Pacific continued a few months longer, the inadequacies of the British Navy in this respect would have been glaringly apparent.

It is a pity we have failed to profit by this lesson of the war and that ten years after there is still no dock in this country in which the hull of a ship can be cleaned to bare metal rapidly and the ship restored quickly to operative duties. Wet sandblasting is a time and labour saver, both scarce commodities in wartime, and is a modern mechanised method of doing a hard and dirty job effectively. Without this equipment the job requires a vigorously supervised large labour force for a long time. Our tardy approach to mechanisation lays us open to a charge of failure to use our manpower to the best advantage, and I feel that it would be difficult to refute such a charge.

Dr. U. R. Evans : The points which have interested me most are those concerning the protection of the wind and water line zone on ships of the Reserve Fleet, because a cementiferous paint was used, covered with two coats of chlorinated rubber-based paints. So far as we can see, the results are satisfactory, because two ships which have been inspected after two years were showing good behaviour at that zone. I am a little puzzled by the choice of the cementiferous paint used. The idea of the cementiferous paints was to protect steel against corrosion. I gave no thought at all at first to avoiding attack by alkalis. As a matter of fact, E.412 appeared to be about the best from the anti-corrosion point of view, but I would not expect it to be the best for resisting alkali because it contains zinc oxide, which is well known to be dissolved, to some extent, by alkali. Some of the other cementiferous paints contain no zinc oxide. I think I know the answer to the question. Presumably, at the wind and water line one has to consider two periods, the wind period and the water period. During the water period there is cathodic protection, and there is danger of alkali formation. During the wind period there is no cathodic protection and consequently you require a paint which is protective against corrosion. Presumably those who had to make the choice chose a paint which was protective against corrosion and not so resistant to alkalis.

This is not just an academic matter ; it has importance at other parts of a ship, apart from the wind and water line. I think the only way to ensure that you get good behaviour from the paint over the whole of a ship is to have a system which is proof against alkaline softening and alkaline peeling. Some years ago there was a commercial paint which did well in marine situations generally, but now and then it was found to be peeling off quite large areas. It was studied along with many other paints in a research which I published in the *Journal of the Chemical Society* in 1929, Vol. 5. I am led to make a suggestion which may be worth considering as a means of overcoming this trouble. It would appear that one might first apply one of the cementiferous paints which is more resistant to akali and has less anti-corrosive properties ; one does not need the anti-corrosive properties if this part of the ship is to receive cathodic protection. If one can find a paint which is sufficiently resistant to alkali, then the application of outer sealing coats of an organic character would probably do the trick, because they are not likely to peel off, but will sink into the cementiferous coat, which is quite porous ; I think there would be at least a chance of achieving good adhesion.

Mr. W. G. Waite : There is reference to the wastage experienced on ships' propellers and there appears to be a general impression that the so-called cavitation erosion results from an action which is unusual, in so far as it is mechanical. I can offer evidence to show that it can be prevented by cathodic protection.

With regard to the method of rigging steel anodes I should have thought that the suspension illustrated would have failed in a comparatively short time, with the loss of the anodes themselves, and I should like to know what was the appearance of the anodes when they came out of the water, whether they attained this 75 per cent efficiency of consumption which I assume is indicated from the paper. Looking at the design, I suggest that advantage can be taken of interference effects to lessen the possibility of losing metal at the welded joints.

Mr. A. J. Sims: I am interested in the electrode described in Appendix I of the paper, and wonder whether it is capable of producing a potential survey over the hull as a whole, as distinct from producing the beam potential of the hull as a whole. I ask the question because I have always had a feeling that different sections, probably of slightly different compositions or subjected to different treatments in manufacture, tend to produce inter-chemical activity. If the reference electrode referred to is capable of producing a potential curve for the hull as a whole, I should be interested to know what sort of difference of potential has been measured in different parts of a ship's structure. It is stated that a ship under way requires 50 per

cent more current than when moored in a tideway, and presumably requires three times as much current as when she is in a non-tidal basin. It would be interesting to know when the increase occurs and whether the requirement remains more or less stationary over a fair zone of the ship's speed. May we say that the current required between speeds of 15 knots and 30 knots remains fairly stationary, or does it vary a lot with increase of the ship's speed ?

Mr. G. A. Bassett : I ask the authors whether you should limit your current to the extent that you do not produce hydrogen, in which case you do not produce the marbling effect which protects the steel structure. You cannot have it both ways. There is no question that there is a great future for cathodic protection, not only for ships which are laid up, but for any structures fixed in the earth. We are not so backward in respect of sandblasting as some people think. More than twenty years ago we did sandblasting in this country on a ship and two years ago we attempted to get shipbuilders to accept sandblasting for some ships, but it was turned down, on account of cost. The fault lay in the system which enables regulations to be applied which prevent the use of the method unless you have so many people to do this, that and the other.

The Chairman : About sandblasting, has anybody gone in for the latest burning method ? It will save all this 300 tons of sand and also the labour to deal with it.

Mr. Tait : In the paper there is a suggestion that a small magnesium anode has a lower efficiency than a larger one ; possibly the authors will comment on that. There is also a reference to the effect of cathodic protection on the fouling of a hull. The authors appear to be in considerable doubt as to whether there is any effect on the fouling, and since nobody is quite certain, I will refer to my own experience in this respect. Recently two reports came from Australia, stating that two cathodically protected ships were fouling in a perfectly normal manner. Just as it seemed that the problem would be solved on a statistical basis we had a reversal of that view and the last half-dozen cathodically protected ships in this country to be inspected have all shown very little or no fouling. Any information the authors care to publish on their present experiments will be greatly appreciated.

It is stated that " when under way the ship requires more current for cathodic protection than when at rest. Variation of current is therefore necessary to avoid over-protection (with consequent damage to the paint coatings) when the ship is stationary. The second of these requirements clearly favours the use of an impressed current system." I sat in the engine-room of the ship mentioned in the paper. When the ship was stationary one observed so many amperes ; when it was under way the current went up automatically. There is a certain amount of automatic effect which is of great advantage, particularly in a merchant ship. So that the authors may care to comment on their point that the second of these requirements favours the use of an impressed current system. The authors say that the points to be considered when deciding to apply cathodic protection during fitting out are (*a*) the ship may be moved to different berths, (*b*) the draught and wetted area will increase and consequently the current demand, and (*c*) other ships alongside will steal some of the protective current. I think there may be a danger that these points will be regarded as the only ones to be considered. There are many others, such as that welding operations are carried out during fitting out ; also, most yards are up rivers, and the salinity of the water varies with the tide and the season.

Mr. A. J. Merrington : The authors refer to cathodic protection applied to the internal compartments of a ship, and point out the limitation of the magnesium anodes and rather suggest that zinc anodes offer the best proposition in this direction.

We have recently undertaken an investigation into the general hull maintenance of the Fleet and have examined a large number of hull inspection reports for frigates and cruisers, and have made a very simple and rough classification. The analysis showed that the black spots were in the lower deck forward and aft, which were three or four times as bad as the outer bottom plating near the fuel tanks. The lower deck fore and aft in these small ships is subject to alternating wetting and drying ; I would like to know whether the authors see any possibility of dealing with this particularly black spot in the light scantling ships by cathodic protection.

Mr. A. P. Cole : The authors have made reference to developments in America and Canada, but have omitted any reference to the important experiments carried out by the Dutch. The Dutch have fitted this cathodic protection externally on the bilge keels in one of their ships, which is at present on a voyage to the Far East and will be back in six months. In the protection of piling they have found copper anodes most effective in removing marine growths. The Dutch have found that in addition to the cathodic coating, which the authors mention in the paper, there was an electrochemical change in the electrolyte. In connection with ships' circulating water, such as in sanitary systems, diesel machinery, &c., the method was to put the anodes in a reaction tank in the circuit, and generally they found that aluminium anodes were the best. I cannot explain what they do, but in one Canadian merchant ship good results were obtained and the shipowners specified the system for all their ships. In a Canadian frigate which had trouble with diesel machinery, there was intense corrosion of cylinder liners and heavy scale deposit. Iron anodes were fitted and lessened the scale, and after replacing a cracked liner they fitted aluminium anodes in the circuit. That was five years ago, and a recent report showed that it is satisfactory and the ship is still in service.

Mr. J. H. Morgan : With regard to graphite anodes, graphite is consumed at approximately one-fifteenth of the rate of steel, so that the surface area effect is not that which entirely controls the resistance of the anode, because a low resistance can be maintained where the shape can be controlled. The usual shape for graphite is a long and thin rod ; this shape cannot be used in steel because the corrosion is unpredictable and the anode might be lost. In the diagram of the laid-up ship the authors have suspended the anodes close to the ship. That is not necessary, and it would be to greater advantage if they had the anodes in a pack fill, of something like coke breeze, some distance away ; they would prevent channelling and would have been able to protect several ships.

Mr. J. H. Krietemeijer : The authors mention the removal of millscale from plates and sections, and say it can be done by pickling and weathering. New methods are being developed on the Continent, and in my shipyard we have a machine which descales plates and sections by steel grit blasting, and the work is done fully automatically. A plate goes through the machine at a speed of about 4ft per minute. It is not only the shipowners who want ships descaled, but shipbuilders also, because derusting ships on the berths by means of brushes is a very dirty job. We intend to paint the sections when coming out of the welding shops, so that when the ships are erected on the berths they are fully painted, except for the seams and butts which have to be welded on the berth. We use a so-called welding primer with which we can paint the whole sections, the butts and seams as well, so that we can weld over the paint.

Mr. John West : In the case of a cargo ship about 500ft long the cost of fitting sacrificial anodes to protect it is about £2000. In addition, every twelve months there is an expenditure of about £1000 for renewing the anodes, so that in the life of the ship the expenditure on its protection is roughly £25,000. From our records we find that the expenditure on renewing shell plates for a ship is well below £25,000. On the average, the shell plates which are renewed most frequently are the keel plates, and I suggest that possibly the major reason for having to renew keel plates so regularly is that they are so rarely painted. One of our rules is that when we lay a new keel, the keel plates should first be painted, so that a keel plate, having been treated initially, should more or less last the life of the ship. We hope our repair bill for renewing keel plates will be practically nil.

My experience is that flame scaling has one particular advantage which nothing else has. In our climatic conditions, particularly on Clydeside, it rains fairly regularly and we are able to apply the wash primer while the steel is still warm, and get a good bonding of the paint, which will stand up to wear and tear for a considerable period. I think this is a great asset in flame scaling, and it goes a long way to protect the hull, although I do not say that cathodic protection is not necessary. I have compared two ships, one of which was cathodically protected and the other was not ; both of them were flame scaled. There was absolutely no difference between them when they were dry docked after the short period of four months. The cathodic protection was not able to assist much because the flame scaling and the application of the wash primer did all that was required.

Technical Report

Notes on Applied Science No. 11, " *Wind Effects on Bridges and other Flexible Structures.*" H.M. Stationery Office, price 1s. 6d.—The latest in the series, of " notes on applied science " is based on wind tunnel research at the National Physical Laboratory. It deals with wind effects on bridges and other flexible structures. In recent years the National Physical Laboratory has carried out extensive investigations on the oscillatory effects of winds on two proposed suspension bridges—the Severn Bridge between Beachley and Aust and the Runcorn-Widnes Bridge over the River Mersey. Most of the booklet is concerned with the oscillatory effects but static wind loads are also mentioned. Much of the content applies in principle to other flexible structures, such as tall chimney stacks, transmission lines, buildings, and so on.

Bridges fail because of static and dynamic actions of wind. The static effect is the tendency to give the bridge a steady deflection. The dynamic effect is the tendency to set the bridge oscillating. Dynamic effect can occur in two ways. First, and most important, are the oscillations that are set up in steady winds due to the interaction of the bridge itself with the air stream. They can be prevented by proper design. Second are the oscillations due to immersion in a disturbed airflow such as the eddying wake of a nearby bridge. The experimental methods used to investigate these three effects of wind on bridges are discussed in detail in the booklet. Illustrations of the equipment used and of models undergoing tests in wind tunnels are included.

Milk Bottling and Processing Centre

A MILK bottling and processing centre recently opened by the Express Dairy Company, Ltd., at Morden, Surrey, provides a good example of the use of modern mechanical handling equipment and process control. With a staff of about 200, the centre is capable of handling up to 1,100,000 bottles, holding a total of 12,000 gallons of milk a day, and it supplies fifty retail distributing branches of the firm. The organisation is such that from the time bottles are collected from the doorsteps of consumers until they are returned washed, filled, capped and sealed, they are untouched by hand.

Milk is delivered to the centre by road and rail tank vehicles and after testing is pumped to the processing floor. Fourteen stainless steel storage tanks on this floor are each capable of holding 3000 gallons of milk, and during storage the milk is agitated by low pressure air to ensure even distribution of the cream content. Milk from these tanks is pasteurised in four stainless steel heat exchange units, having a total capacity of 8000 gallons an hour, before being piped to the bottle-filling section.

At the other end of the plant crates of incoming dirty bottles are delivered by road vehicles and stacked along the edge of a bay which runs along the length of a large open floor area serving the five bottle-washing machines. Each washing machine is fed by its own unloading line in accordance with the size of bottle it handles. Fork lift trucks transfer the crates in stacks to the head of the appropriate line where they are loaded in turn on to a slat conveyor. This conveyor leads to a twin-headed, air-operated, bottle "de-crater," such as can be seen in the foreground in one of our illustrations.

As a crate comes to a halt below this machine a head is lowered over the bottles by the operator and a series of rods register between the lines of bottle-necks. As the head is then raised a pneumatic mechanism comes into effect to close the rods on the bottle-necks to raise the bottles out of the crate. The head is then swung through 180 deg. on the pillar of the machine to register over a bottle conveyor—at the same time the other head comes into the "de-crating" position. When this second head is lowered for the next operation the first head is lowered a short distance and its rods are moved apart to release the bottles on to their conveyor. The bottles on this conveyor are carried to a magazine, whence they are fed automatically into the holders of the washing machine.

As the bottles pass through the washing machine they are successively externally pre-rinsed, internally pre-rinsed, washed twice in detergents, washed in warm water and finally rinsed by cold water. Each rinsing and washing operation is carried out by powerful jets of liquid and in the sequence of operations a gradual ascending and then descending temperature gradient is maintained. At the end of a draining period the bottles are discharged from the machine in the adjoining filling department shown in the second illustration.

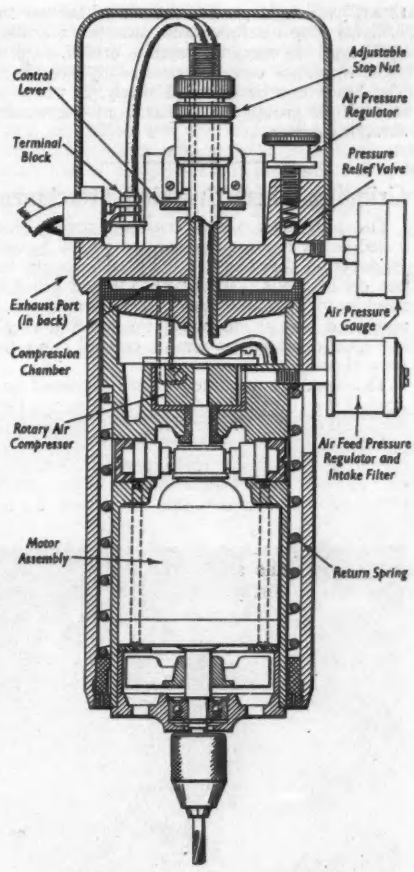
The clean bottles are discharged on to a double-lane conveyor, each lane of which feeds an automatic vacuum controlled filling machine, followed by an automatic capping machine. They conveyors from these machines lead to a crating station where a machine similar to that used in the first place for removing the bottles from the crates is used to re-crate them. The crates of full bottles are taken by conveyor to a loading bay, where they are stacked on fork trucks and loaded on to vehicles for despatch to the distribution centres.

Automatic Drilling Head

AN automatic drilling head of interesting design made by the Dumore Company of the United States, is now being distributed in this country by Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11. The head is fitted with a $\frac{1}{4}$ h.p. motor and its chuck takes drills up to $^{6}/_{32}$in for drilling plastics, wood, &c., and $^{5}/_{32}$in for mild steel. A vane air compressing mechanism incorporated in the head supplies compressed air which is used for automatically feeding the drill, and as a means of controlling the speed range from 2500 to 7500 r.p.m., in accordance with the material being drilled.

The general construction of the head can be seen in the diagrammatic drawing we reproduce here. Its motor shaft is extended at the inner end to carry the rotor of the vane compressor, the air inlet of which is fitted with a combined air feed pressure regulator and inlet filter. The motor compressor assembly forms a piston sliding within the main housing of the head, and the upper part of this sliding body is fitted with a combined cup washer and bearing. The cylindrical lower part of the body in which the motor is enclosed slides in long bearings in the housing bore. A spring in the annular chamber between the housing and sliding piston assembly holds the assembly in its uppermost position.

When the drill motor is running and the control lever is depressed, the compressor feeds a constant supply of air at a preset pressure into the chamber between the head of the sliding assembly and the top of the cylinder formed by the housing. This supply of compressed air overcomes the upwards pressure of the spring and serves to push the sliding assembly out of the head to feed the drill into the workpiece to a maximum depth of 1$\frac{1}{4}$in.

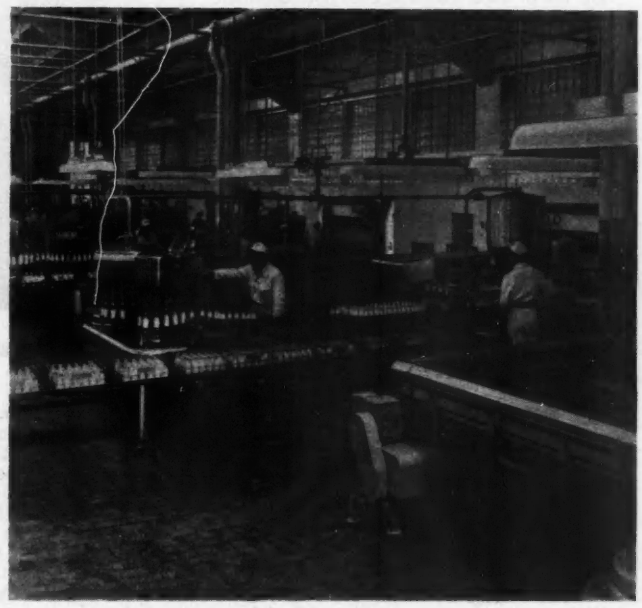


Arrangement of automatic drilling head

The depth of the feed is controlled by a stop nut at the top of a tubular extension of the sliding head through which the motor power supply leads are taken. The air feed pressure regulator can be set to provide pressures up to 15 lb per square inch and its setting combined with the action of the return spring controls the rate of drill feed and drill speed.

If required, the makers can supply for use with the machine what is termed a "repeat cycle

De-crating machine which picks up empty milk bottles from the crates and deposits them on a conveyor belt feeding a bottle washer



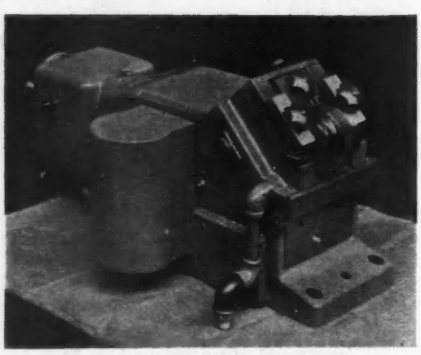
Bottle filling room in which each of ten machines fills and caps ninety bottles per minute

timer," which at preset intervals withdraws the drill for chip clearance and restarts the drilling cycle until the required depth is drilled. Up to eight machines can be operated by this timer. The heads can be operated singly, in pairs, or in multiple groups controlled from one master actuating switch.

Grinding Wheel Crushing Attachment

THE automatic wheel crushing device illustrated below has been introduced by the Newall Engineering Company, Ltd., Peterborough, for use on its "N.L." (type "D") thread grinding machine. The attachment is mounted on a machined base at the rear of the grinding wheel, but it is operated by remote control from the normal position.

The spindle is mounted in two hardened and ground vees on the head and is held in position by screw clamps. Lateral adjustment is provided for the crusher roller, which is carried on a drum rotating on two dual-purpose bearings on the spindle and retained by a threaded collar. The roller is washed by an internal jet of coolant during the crushing operation and a brush is fitted to sweep off any adhering grit.



Front of attachment set up for crusher forming of a thread

The slideways carrying the crushing head are connected by internal channels and, together with the feed screw, are lubricated from oil nipples. Lubricant is supplied to the crusher roller bearings through a grease nipple. Feed of the crusher is applied by operation of a push-button at the front of the machine. Each depression of the button feeds the crusher 0·001in and the makers recommend that the maximum feed per cycle should not exceed 0·004in.

The use of the attachment does not necessitate the removal of a component set up on the machine. The only extra equipment required on a machine is a special planetary pulley through which the grinding wheel is driven.

Multiple-Unit Diesel Train Equipment for British Railways

IN the article in our last issue dealing with the main projects involved in the modernisation plan for British Railways, it was mentioned that one of the biggest items would be the provision of multiple-unit diesel trains. We have since been informed by British United Traction, Ltd., that it has received orders to the value of £4,070,000 from the British Transport Commission, for 848 sets of running units for twin-engined power cars and 443 sets of trailer car equipment. These equipments will be fitted to the vehicles made by four main contractors—Cravens, Ltd., Gloucester Railway Carriage and Wagon Company, Ltd., Birmingham Railway Carriage and Wagon Company, Ltd., and Metropolitan-Cammell Carriage and Wagon Company, Ltd. The accompanying illustration shows a typical multiple-unit diesel train which is now in service.

The running units, designed by British United Traction, Ltd., specifically for multi-engined railcars, consist of engines, gearboxes final drives and controls. They can be mounted under existing passenger rolling stock to convert them to diesel operation, or they can be incorporated in new coaches which are now being built. Two kinds of diesel engines will be supplied, which are interchangeable with each other. They are horizontal engines, the B.U.T. "A" type of 11·3 litre capacity and the "L" type of 11·1 litre capacity, each developing 150 h.p. at 1800 r.p.m.

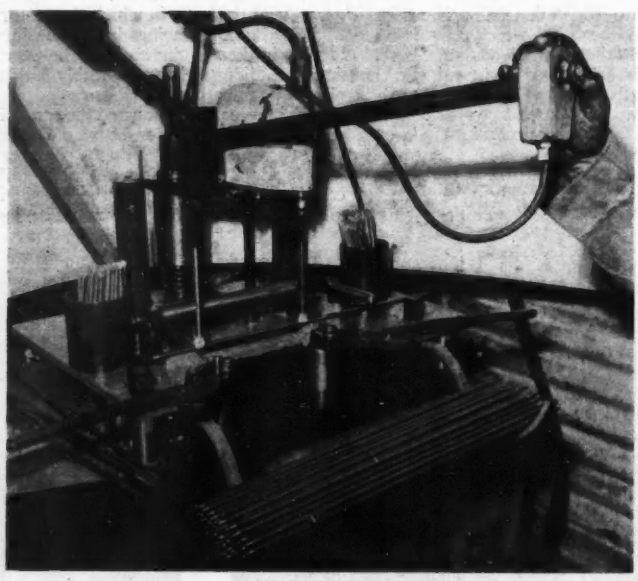
Two-car lightweight diesel train in service on the North Eastern region

On a power car two horizontal engines are mounted practically nose to nose under the floor. One engine drives the inside axle of the front bogie, and in a similar manner the other drives the inside axle of the rear bogie. Equipment for each power car, therefore, comprises two diesel engine driving assemblies, each complete with a fluid coupling, driving shaft with a freewheel incorporated, electro-pneumatically operated four-speed epicyclic gearbox, and a double-reduction final drive. The gear ratios will be specified according to operating conditions and the routes on which the cars will run.

In the control mechanism safety devices are fitted to protect the engines and mechanical parts in service. One of these safety devices enables the train to continue its run without damaging an engine which has stopped due to mechanical failure. Another is the "dead man's" handle, which ensures that should the driver release his control, engines are cut and brakes automatically applied after a five-second delay. The controls, situated at one end of each power car, are arranged so that a number of cars can be coupled together and driven from either end of the train. Up to eight cars (four power cars and four trailer cars) or even more, can be coupled together and controlled by one driver.

Stud Welding for Small Bar Assembly

PARTICULARS have been received from Crompton Parkinson, Ltd., of a jig and procedure developed by the firm's stud welding organisation to facilitate the manufacture of flare pickets at the works of the Mason Engineering Company Ltd., Northampton. The work entailed the stud welding of two ¼in diameter pins, one 5·8in long and the other 6·3in long, on to a ¾in diameter rod 1ft 11in long. Each of the ¼in pins is then bent at right angles at a preset position.



Stud welding the right-hand picket pin. The bending fixture can be seen in front of the jig

The equipment and method of operation can be seen in the illustration. The picket rod is placed in vee blocks and abutted against an end stop. One of the pins, together with a special concave ferrule, is then loaded into the welding head, which is mounted on a swivel above the blocks. This head can be lowered to either of the two welding positions, its location being controlled by pillar slides which limit the swivelling movement; other pillars limit its downward movements. Loaded with the first pin, the welding head is drawn down the left-hand slide by means of a counterweighted lever and the first weld is effected by pressure on the push button switch mounted conveniently on the lever. For the second weld, the operations are repeated with the welding head loaded and swivelled to its opposite setting and drawn down the right-hand slide.

For bending the pins the picket rod is rotated through 90 deg. and clamped in the vee blocks so that the pins lie flat in a double-handed bending fixture at the front of the jig. Operation of the hand levers on each side of the bending device then effects the two right-angular bends simultaneously.

The production cycle time for each picket is stated to be twenty-five seconds.

35,000-Ton Closed-Die Hydraulic Forging Press

THE first of the very large closed-die hydraulic forging presses, which were designed and built for the U.S. Air Force heavy press programme went into production at the North Grafton Works of the Wyman-Gordon Company near Worcester, Massachusetts, in March. The erection of this 35,000-ton press, which is shown in Fig. 3, began last June and was completed in February. The first forgings now coming off the press are aluminium wing spars for the new "F-102" delta-wing, supersonic, all-weather intercepter being built by the Convair division of the General Dynamics Corporation for the U.S. Air Force. This wing spar is 12ft long, 18in wide at its widest section and only ¼in thick in some areas. Each spar goes through three closed-die strokes before reaching its final contour and specified dimensions, and is heated to a temperature of 800 deg. Fah. for each pressing operation in a battery of gas-fired furnaces. It should be noted, in passing, that there will be four spar forgings in each "F-102" aircraft; these four components will replace 272 parts and will save 3200 rivets per aircraft as well as 100 lb of material, compared with the previous method using many small parts joined together. The wing spars required the manufacture of three sets of dies, which are claimed to be the largest ever made for a forgng press. The dies weigh 148,000 lb and were produced in the new die department of the firm on equipment specially designed and built for this job and for a similar 50,000-ton press which is expected to go into production this autumn.

The hydraulic press was designed by the Loewy Construction Company, of New York, and its components were manufactured by various American and foreign companies. It has a deadweight of 7180 tons, and its "accessories" weigh as much as the press itself. The hydraulic pressure is developed by three 1500 h.p. pumps, and the water storage facilities provided can hold 125,000 gallons. The moving parts of the machine weigh 4050 tons. The press stands 45ft above the operating floor of the forging shop and extends 62ft below it. Its special design is said to make it the most rigid press ever built thus minimising any deflection during forging operations. The four crosshead beams of the machine were cast at the Sheffield Works of the English Steel Corporation and it is thought that (with a weight of 414,000 lb each) they are the largest steel castings made in the British Isles. The beams were sent by special trailer to Liverpool, loaded on the S.S. "American Packer," and unloaded at the Brooklyn Navy Yard because only this yard had an overhead crane of sufficient capacity to handle them. The Pennsylvania Railroad then took two of the beams to the U.S. Naval Ordnance plant at South Charleston, West Virginia for machining. The other two beams were machined at the North Grafton Works of the Wyman-Gordon Company.

The four great columns of the press weigh 630,000 lb each and were assembled from three 101ft 1in long laminations. They are believed to be the longest forgings ever made in the United States and were manufactured by the Bethlehem Steel Company, at Bethlehem, Pennsylvania. To facilitate the machining of these exceptionally long forgings, the travel of three large machine tools at the Bethlehem works had to be nearly tripled. The rectangular column sections were forged from ingots 108in in diameter and weighing 500,000 lb each. In the machine shop, a roughing cut of 1in on all main surfaces was removed on a planer whose normal stroke was 36ft. The work table travel had to be virtually tripled to machine the full length of the workpiece and this effect was accomplished by supporting the ends of the long column piece on bogies running on trackwork extending about 100ft in both directions from the cross-rail (Fig. 1). The trackwork comprised accurately levelled and aligned special-gauge industrial rails laid on industrial steel ties grouted into the concrete floor of the shop. One-third of the heavy member was planed at a time, using the regular reciprocating work table. For the two end cuts, both bogies were placed under the opposite, protruding end of the member. For the middle cut, the centre of the member lay on the planer table while a bogie supported each one of the dumbell-shaped ends. Despite the great weight of the piece, the 12ft by 12ft planer performed smoothly at its usual cutting speed of 20ft to 25ft per minute, with two tool-heads operating simultaneously.

In another part of the machine shop, similar facilities were installed to increase the 40ft stroke of a 10ft by 10ft plano-miller, which offered the advantage of allowing both roughing and finishing cuts to be performed on one and

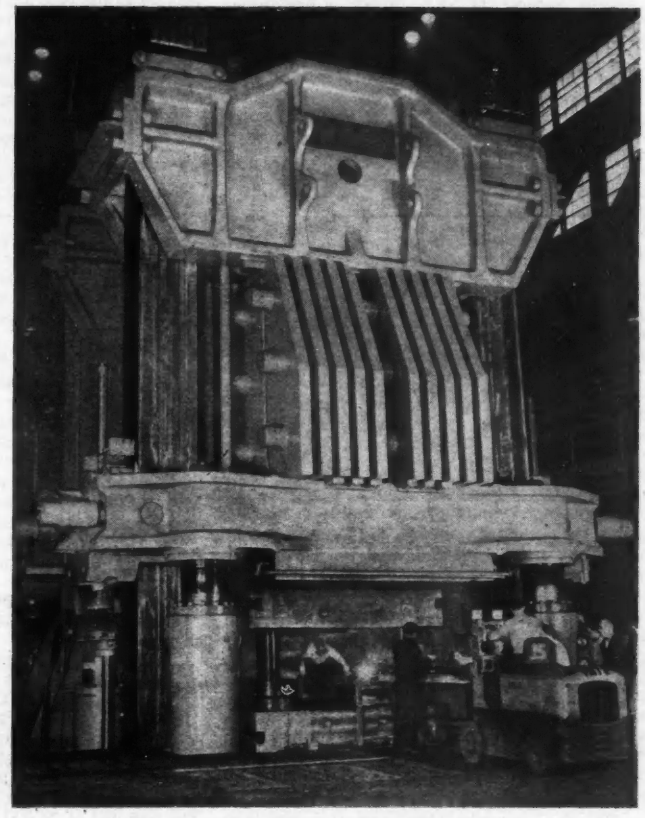


Fig. 3—35,000-ton closed-die hydraulic forging press

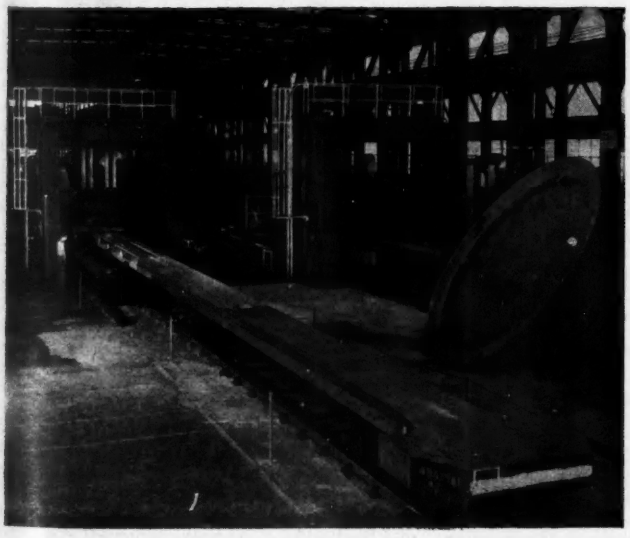


Fig. 1—Special trackwork and bogies supporting the projecting end of a press column lamination being machined on a 36ft stroke planing machine

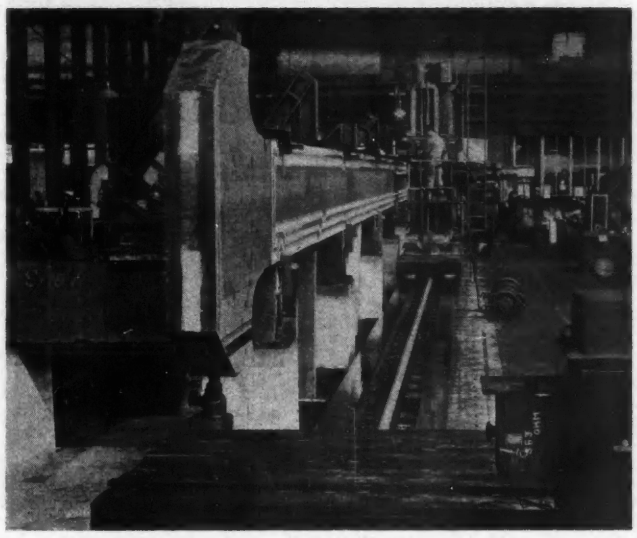


Fig. 2—Milling machine placed on carriage of a boring machine to facilitate machining the full 101ft length of the column laminations in one setting

the same machine. This facility saved one transfer from machine to machine of a cumbersome workpiece with dimensions so large that its handling in the shop demanded careful planning and unusual dexterity. The alignment of the plano-miller was carefully checked for this operation, and the supplementary equipment was installed with the same meticulous care to ensure the accuracy of the final milling cut. Nearly three weeks were spent in laying the rails, to make them perfectly level. A milling cut was even taken along the top surface of the rails to make them absolutely flat.

A particularly interesting improvisation was carried out at the site of a double-end boring machine (Fig. 2, page 719). A horizontal boring and milling machine was placed on the boring machine carriage to afford the miller a longitudinal movement of 105ft, or more than enough to machine the full length of the 101ft long column section at one stroke. Additional motors and gearing were installed to feed the miller against the workpiece, which was held rigidly in place by five welded steel "strong-backs" resting on pairs of concrete slab piers rising 4ft above the shop floor. This machine received the rough-machined piece from the planer and made the finishing cuts totalling $\frac{1}{4}$in. The first finish cut was $\frac{1}{16}$in and the final one $\frac{1}{32}$in. An 18in diameter milling tool was used to reach the wings left on the wide ends of the piece by a 6in diameter cutter.

Fig. 4—Both ends of a laminated press column being machined simultaneously by two horizontal boring mills

The final machine shop operation was also unusual. This called for the "Sandwich" or multiple milling of a complete laminated column, comprising a full set of three members at a time, to ensure accuracy in subsequent assembly. Both ends of the laminated column were worked at once with horizontal boring mills, on a special machine separate from the other operations (Fig. 4). The machine was required to finish-bore a 10in dowel hole at each end and to cut and blend large and varied radii into the concave-shaped support surfaces of the column sections. The dowel holes were rough-bored singly before the assembly of the individual laminations.

Removal of Rock at the Niagara Falls

FOR years severe erosion has been caused at the Niagara Falls due to the extremely swift current of the Niagara River. If ancient records are to be trusted, the crestline of the largely Canadian Horseshoe Falls has receded some 1300ft since 1679, and the American Falls has also suffered considerably—most recently by the 185,000-ton rock slide in July, 1954. Engineers have established that in years to come the magnificent Falls could be worn away to a mere cascade, if the present rate of erosion should continue. Such a prospect dismayed all true lovers of this scenic wonder and also was a disturbing thought to the businessmen of the region, who depend for a livelihood, wholly or in part, upon the 2,000,000 tourists who visit the Falls each year. Furthermore, it was felt that any substantial reduction of the present crest by erosion would lessen the capacity of the river for hydro-electric power production. The U.S. Army Corps of Engineers therefore undertook a preventive measure: excavation at strategic points, to improve the distribution of water descending over the Falls. Corresponding work on the Canadian side of the river was noted in our issue of October 1st last, when the new Canadian hydro-electric works at Niagara were described. A particularly difficult part of the work involved the removal of 24,000 cubic yards of rock from the Goat Island side of the Horseshoe Falls. Goat Island is a great and stubborn slab of land that defies the swift current of the river, though flanked on one corner by the Horseshoe Falls and on another by the American Falls. The object of the rock removal is to create a more equal distribution of water over the horseshoe. The deepest flow in the middle, where erosion has been greatest, will be lessened (Fig. 1). Goat Island lies on the American side of the International Boundary Line, and the boundary apportions a share of the Horseshoe Falls to the United States and a larger share to Canada.

The rock removal work initially required the riverbed near Goat Island to be dried up so that the rock could be blasted out to a depth of several feet. Ordinarily, to build a diversion dam out into the river, a contractor would have floated wooden cribs out and sunk them with rocks. Then a wall of steel sheet piling, backed with rock fill, would have been erected behind the protection of the cribs as a facing for the dam. But, to save expense, the contractor at the Niagara Falls thought of substituting for cribs a specially constructed movable steel shield, rectangular in shape and held in place by powerful steel cables nearly 2in thick. He decided to run two 1300ft long cables to the shield from a concrete and steel anchorage erected upstream on Little Brother Island. He built the shield, which was 26ft long and 20ft high, at the site. Constructed of sheet piling fastened to a frame of I-beams, it was designed to hold back 100 tons of water pressure while men on the downstream side of it constructed a temporary diversion dam. The shield cables were made at the Williamsport Works of the Bethlehem Steel Company and prestressed to prevent the steel from stretching excessively in operation once the cables were placed under the very severe strain. With this ingenious device deflecting the waters, the construction crew was able to erect a temporary diversion dam extending 350ft out into the current. The dam was faced with Bethlehem sheet piling and ballasted with quarry stone. Cranes, a power shovel and other equipment moved out on the stone, which became a serviceable road bed as the work proceeded (Fig. 2). The workmen used safety lines buckled to thick safety belts about their waists and, as an added precaution, a steel safety cage of beams and rods was built to catch any man tumbling into the current. As the dam inched out toward midstream, diverting the water from its usual course, 6 acres of the rocky riverbed below the dam were bared. This made it possible for the dynamite crews to blast loose the rock, which was then taken away and dumped at various fill sites. The riverbed was thus lowered by between 3ft and 6ft. When the excavation was finished the temporary dam and the shield were removed and the normal shore line restored.

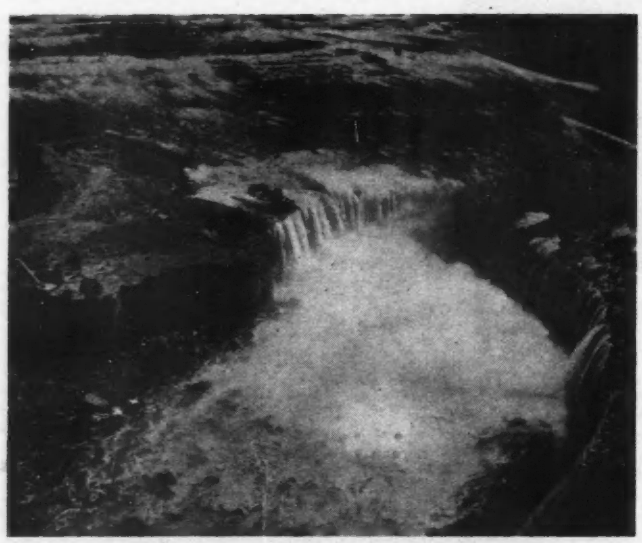


Fig. 1—Aerial view of the Canadian Horseshoe Falls with river bed at left dried up by a diversion dam to facilitate rock removal

Fig. 2—General working area at the Horseshoe Falls dried by right-angle diversion dam

Industrial and Labour Notes

Overseas Trade

The Board of Trade has announced that the value of the United Kingdom's exports in April was £244,800,000. On account of the Easter holiday, April was a short month with only twenty-four working days, but the value of exports was only 1 per cent below the average for the first quarter of the year. In the first four months of the year the value of exports was 10 per cent higher than in the comparable period of last year. Imports in April were valued at £318,100,000, which was 5 per cent below the monthly average for the first quarter. But in the first four months of this year the value of imports was 20 per cent more than in the corresponding months of 1954. Re-exports in April were valued at £8,300,000 and the excess of imports over total exports was thus £65,000,000, compared with an average of £77,100,000 a month in the first quarter of this year.

Industrial Disputes

The annual meeting of the British Employers Confederation was held in London last week. In its annual report the council expressed its concern at the extent of the resort to strike action, often without the official support of the trade unions concerned, which had occurred in many industries during the past year.

The same concern was expressed by the president of the Confederation, Mr. Charles Connell, who suggested that the time had come for a full review of the machinery for handling industrial relations. That machinery, he said, had been built up piecemeal and had been modified to meet particular situations as they had arisen. The law had given privileges to employers' organisations and trade unions, and special arbitration and conciliation machinery had been developed. It might well be, Mr. Connell continued, that few changes would be called for, but, nevertheless, he suggested, the general public was entitled to know that industry was subjecting its own procedures and practices to the searchlight of self-criticism. The real problem was basically one of developing a sense of responsibility in the individual workman, and in that employers and trade unions shared both an interest and a duty.

Incorporated Plant Engineers' Conference

This week the annual conference of the Institution of Incorporated Plant Engineers is being held at St. Annes-on-Sea. Yesterday morning, Mr. G. Sievewright was installed as president for the forthcoming year. In his address to the conference he recalled that, at the time of Queen Victoria's diamond jubilee, Britain occupied what seemed to be an unassailable peak of power and prosperity. The products of our engineering skill were bought eagerly by the peoples of the world, and in payment, the best that the world could offer in food, raw materials and other produce flowed into this country.

It was superfluous, Mr. Sievewright continued, to say that to-day a very different situation had to be faced. Our former customers abroad had created their own manufacturing industries and were now far less interested in buying manufactured goods from us than in buying machinery with which to equip their own industry. Many of our competitors employed labour forces with a lower standard of living and who would work longer hours, and the brief sellers' market, which existed when the world was clamouring to make good the shortages created by the war, had vanished. We must now satisfy, Mr. Sievewright emphasised, exacting standards of cost, quality and delivery, against intense competition, if we were not to know real want and see a serious decline in our standards.

Later in his address Mr. Sievewright said that many well-informed people had suggested that we were on the eve of a second industrial revolution, and certainly there was a wealth of evidence to support that view. Many new and revolutionary techniques were being introduced into industry and their application would become wider and more intense. This, Mr. Sievewright reminded the conference, could only mean an increase in the problems—and they would not only be technical problems—that would face the engineer of tomorrow. It was essential, therefore, he urged, to do everything possible to ensure that young engineers received training which would equip them to meet their responsibilities.

Gas Statistics

The Gas Council has stated that in each of the first three quarters of the financial year 1954–55, gas consumption was over 4 per cent greater than in the corresponding period of the preceding year. Industrial gas sales were at a high level in each quarter, and in the nine months ended last December were 9 per cent higher than in the corresponding period of the preceding year. The increased sales were met mainly by increasing the production of water gas. Production of coal gas in the nine months ended December, 1954, increased by 1·5 per cent and the quantity of coal used by 1 per cent. Water gas production increased by 21 per cent and the use of oil in water gas by 27 per cent. The quantity of surplus gas purchased from coke ovens and oil refineries increased by over 7 per cent. The Gas Council's report adds that new gas-making capacity to a total of 99,000,000 cubic feet per day was brought into operation during the nine-month period ended December last.

Iron and Steel

Steel production in Great Britain in April averaged 393,400 tons a week, and was thus at an annual rate of 20,455,000 tons. The Iron and Steel Board says that this was the highest production ever recorded for April and compares with a weekly average of 368,300 tons in April last year. In both years, April output was affected by the Easter holidays. Pig iron production in April averaged 238,500 tons a week, compared with 212,700 tons in April last year.

Industry's Prospects

In a statement issued with the annual report of G. and J. Weir, Ltd., the retiring chairman, Viscount Weir of Eastwood, comments that since the beginning of the year the Government has been examining, with encouraging inspiration, a plan which will revolutionise the technology and conduct of the railways. Next, he continues, "our roads are no longer to make us blush with shame." It has now been thoroughly realised that the country's road system can constitute a real dividend-paying investment. Lord Weir goes on to say that a new and healthy atmosphere is to be created in the administration and organisation of the coal industry, the programmes and policies of the defence departments are to be reviewed in the light of scientific progress affecting both strategy and tactics, and the national steel production is to be pushed up to 22,000,000 tons a year. Finally, the statement remarks, there is advice of a long-term programme and plans for the development of electricity supply from atomic fuel. These interesting and important factors, Lord Weir says, represent a real degree of justifiable faith in the country's future. But, he adds, these matters lay fresh and heavy responsibilities upon the engineering industry. They appear to call for new technologies, and in engineering, Lord Weir observes, "we must prepare for the implications of these new burdens."

Industrial Investment

Some observations on this country's economic conditions during the past twelve months are made in a statement by Lord Piercy, chairman of the Industrial and Commercial Finance Corporation, Ltd., which accompanies the annual accounts. Lord Piercy refers to the past year as a period of exceptional prosperity. Nevertheless, he says, it has been necessary for the authorities to recognise, and to take immediate measures to correct the tendency to inflation. The statement goes on to say that the excellent company profits of the past four or five years have provided both the means and a favourable background for investment. Then, apart from the investment programmes of large companies and nationalised industries, a good deal has been done quietly by concerns of small and medium size with which the Corporation is chiefly concerned. Retained profits have accumulated, the statement continues, and in many cases are now substantial. There has also been recourse to the issue market by small and medium companies to take advantage of the favourable conditions of access in that market during the last two years. Lord Piercy adds that the Corporation's experience during the past year shows that the business done has included a larger proportion of new buildings and fixed plant investment than in earlier years.

Professional Engineers' Appointments Bureau

The annual report of the Professional Engineers' Appointments Bureau records that last year particulars of over 9000 engineers were submitted by the Bureau for vacancies notified in civil, mechanical and electrical engineering. This, it is stated, is the highest annual number of submissions since the establishment of the Bureau in 1947.

The report goes on to say that, as a result of this work, there have been many placings in all three branches of engineering, and there has been an increase in the number of registrations with the Bureau, many of them from overseas. But, the report comments, because of the full employment position, there is a reluctance on the part of many engineers to change their employment unless substantial benefits are likely to result. The Bureau says that the principal demands in civil engineering have been for engineers with extensive design experience and good contracting experience, and for young engineers who are prepared to accept posts overseas. There has also been a big increase in technical vacancies notified by local authorities. In mechanical engineering, the requirements have been varied and have included posts for engineers with experience in chemical engineering plant, hydraulics, servo-mechanisms, production and management. The major proportion of vacancies in electrical engineering have called for experience in electronics and instrumentation. The Bureau points out that its task is not only to find a post suitable to an engineer's experience, but also "to seek to satisfy the numerous conditions made both by the applicant and by the employer." The Bureau continues to operate from 9, Victoria Street, London, S.W.1.

Coal Production

The unofficial strike in the Yorkshire coalfield ended last Saturday, and reports indicate that there was a general resumption of work on Monday. The strike began at Markham Main colliery over a dispute concerning the revision of fillers' rates. It lasted for nearly three weeks and is stated to have involved, directly and indirectly, nearly 90,000 men. The loss of deep-mined coal through this unofficial stoppage has been estimated at just over 1,000,000 tons.

The total saleable output of coal in Great Britain last week was 4,056,900 tons, of which 3,824,300 tons came from the deep mines and 232,600 tons from opencast sites. In the comparable week of last year, total production was 4,556,200 tons. The loss of deep-mined coal last week through disputes is put at 570,800 tons. Figures issued by the Ministry of Fuel and Power show that in the first nineteen weeks of this year, the total saleable output of coal from the deep mines and opencast workings was 83,245,000 tons, which was approximately 2,000,000 tons below the quantity raised in the comparable period of last year. In the first eighteen weeks of this year, coal imports amounted to 3,942,700 tons. Distributed stocks on May 7th totalled 10,967,000 tons.

Personal and Business

Appointments

MR. HANS BRONNIMAN has been appointed works manager of Lake and Elliott, Ltd., Braintree, Essex.

MR. S. L. FINCH has been appointed joint managing director of Catton and Co., Ltd., Yorkshire Steel Foundry, Leeds, 10.

THE FEDERATION OF BRITISH INDUSTRIES announces the appointment of Major H. M. Burton as its liaison officer for the Middle East.

MR. V. LEHEL, A.M.I.Mech.E., has been appointed chief engineer of Alfred Wiseman and Co., Ltd., Glover Street, Birmingham, 9.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces the appointment of Mr. H. Thomson as manager of its Glasgow branch.

MR. ROBERT S. STEVENSON has been elected president of the Allis-Chalmers Company, in succession to the late Mr. William A. Roberts.

SIR PATRICK HAMILTON, Bt., has been appointed vice-chairman of The Expanded Metal Company, Ltd., Burwood House, Caxton Street, London, S.W.1.

HATHERNWARE, Ltd., Hathern, Loughborough, states that Mr. N. Tanner, chief draughtsman, has been appointed to the board, following the retirement of Mr. C. E. Taylor.

MR. W. T. TOWLER, of Towler and Son, Ltd., and Mr. G. S. Wood, of Thos. W. Ward, Ltd., have been elected to the governing council of the British Engineers' Association.

A.P.V.-PARAMOUNT, Ltd., Crawley, announces the appointment of Mr. D. N. Manton as Midland area representative and of Mr. E. L. Illsey as representative in the North of England.

THE SOUTH EASTERN ELECTRICITY BOARD announces the appointment of Mr. J. C. Poole, A.M.I.E.E., as deputy engineer-in-chief, in succession to Mr. E. H. Skinner, who has recently become chief commercial officer.

CROMPTON PARKINSON, Ltd., announces the appointment of Mr. A. F. Kistner as general manager of its associated company, Cooke and Ferguson, Ltd., Manchester. He succeeds Mr. J. R. Ferguson, who has resigned.

JOHNSON AND PHILLIPS, Ltd., Charlton, London, S.E.7, announces the following appointments: Mr. W. S. Penn, chief rubber cable technologist; Mr. V. Rodman, rubber cable chemist; Mr. H. J. Wigner, senior sales engineer.

MR. J. J. COLLETT has been appointed training officer of the Council of Ironfoundry Associations, 14, Pall Mall, London, S.W.1. He will advise the Council on all matters relating to the training of personnel in the ironfounding industry.

THE NATIONAL COAL BOARD states that Mr. A. Scott has been appointed production director in the North Eastern Division. He succeeds Mr. H. A. Longden, who has been appointed director-general of production at the Board's headquarters.

MR. JOHN HILL has been appointed managing director of Capamianto S.p.A., Turin, the Italian subsidiary of The Cape Asbestos Company, Ltd. He succeeds Mr. E. R. Williams, who has retired after thirty-five years in the company's service.

MR. E. V. SMALL, managing director of B.T.H. Export Company, Ltd., has been elected to the board of The British Thomson-Houston Company, Ltd., Rugby. Mr. D. N. Relf, A.M.I.E.E., has been appointed assistant manager, switchgear contracts, at the B.T.H. Willesden works.

THE CANADIAN PACIFIC RAILWAY COMPANY announces the appointment of Mr. D. S. Thompson, of Montreal, as vice-president with jurisdiction over all its lines. He is succeeded as vice-president, operation and maintenance, by Mr. R. A. Emerson, who has been chief engineer since 1951.

MR. E. L. GETHIN, A.M.I.E.E., has been appointed supplies and production adviser to the British Transport Commission. Mr. Gethin, who will take up this appointment on June 13th, will be responsible for the proper utilisation of the Commission's industrial facilities and for the co-ordination of purchasing programmes.

THE BRITISH MOTOR CORPORATION, Ltd., has announced the appointment to its board of Mr. Arthur Keats, chairman and managing director of Fisher and Ludlow, Ltd. The Corporation has also announced the following appointments: Mr. J. F. Bramley, Mr. J. R. Edwards and Mr. S. J. Wheeler, directors of The Austin Motor Company, Ltd., and Mr. A. J. Burton, Mr. G. A. Durant, Mr. J. Tatlow, and Mr. G. C. Tuck, local directors of that company. Mr. J. R. Woodcock has been appointed deputy managing director of Morris Motors, Ltd., and Mr. G. M. Palmer has been appointed a director. Major-General E. H. Clayton, Mr. W. E. A. Cullum, Mr. E. C. Dickinson, Mr. L. W. Hewson, Mr. J. W. Malone, and Mr. T. Sangster have been appointed local directors.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, announces the following appointments in its electronics department: Mr. E. T. W. Barnes, superintendent; Mr. D. E. Thornhill, assistant superintendent; Dr. L. W. Brown, chief engineer; Mr. T. R. Goode, assistant chief engineer; Mr. J. L. Russell, assistant chief engineer (special applications); Mr. L. H. J. Phillips, sales manager and Mr. J. Nicholson, assistant sales manager. Mr. G. W. G. Canter, who has been appointed manager (special contracts) now has his office in London.

METAL INDUSTRIES, Ltd., Universal House, 60, Buckingham Palace Road, London, S.W.1, announces the appointment to its board of Mr. J. O. Knowles, chairman and joint managing director of Brookhirst Switchgear, Ltd., and Mr. J. T. Rymer, managing director of Sentinel (Shrewsbury), Ltd. Sir Charles Westlake has also been appointed to the board of Metal Industries, Ltd. Mr. R. W. McCrone is retiring from the board after thirty-three years as managing director, and latterly, as chairman, and he is to be appointed an honorary president of the company. Mr. J. S. Hutchison is to succeed Mr. McCrone as chairman.

Business Announcements

SIR IVAN STEDEFORD, chairman of Tube Investments, Ltd., has left for a tour of Canada and the U.S.A.

THE GENERAL ELECTRIC COMPANY, Ltd., has opened new branch premises in White House Road, Ipswich.

JOHNSON AND PHILLIPS, Ltd., has opened a new depot at 91, Spital House, Spital Hill, Sheffield, 4 (telephone, Sheffield 22893).

ABELSON AND CO. (ENGINEERS), Ltd., states that the telephone number of its London office at 60–62, Clapham Road, S.W.9, has been changed to Reliance 7081.

BENNIS COMBUSTION, Ltd., Little Hulton, Walkden, Lancs, states that, following an agreement with Todd Oil Burners, Ltd., it is now able to provide complete oil-burning installations for shell and water-tube boilers.

CONSOLIDATED PNEUMATIC TOOL COMPANY, Ltd., 232, Dawes Road, London, S.W.6, states that it has made an agreement to take over virtually world-wide representation for "Hemborn" dustless dry drilling equipment.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., Telcon Works, Greenwich, S.E.10, has established a new factory at Wadeville, Germiston, Transvaal, through its subsidiary company, Telcon Africa (Pty.), Ltd.

THE A.P.V. COMPANY, Ltd., Wandsworth Park, London, S.W.18, has formed a new company entitled A.P.V. (Canada) Equipment, Ltd., to take over Walker-Wallace, Ltd., Toronto. Walker-Wallace, Ltd., has been Canadian agent of The A.P.V. Company, Ltd., since 1929.

ATLAS DIESEL COMPANY, Ltd., states that its Scottish office and service depot have been moved to 591, Nitshill Road, Glasgow, S.W.3 (telephone, Barrhead 2346). The company's South Wales office has been moved to 27, Wyndham Crescent, Cardiff (telephone, Cardiff 31161).

ENGLISH STEEL CORPORATION, Ltd., announces the formation of a wholly-owned subsidiary company under the name of Davis and Lloyd (1955), Ltd. It has taken over the interests of Davis and Lloyd, Ltd., 26, Victoria Street, London, S.W.1, in the design and production of cast steel parts for railway rolling stock. Mr. F. Pickworth has been appointed chairman, and Dr. C. J. Dadswell, managing director, of the new company, the other directors being Mr. F. S. Beale and Mr. F. Mason. Mr. Ernest Lloyd, formerly chairman and managing director of Davis and Lloyd, Ltd., has retired, but will be available to the new company as a consultant.

Contracts

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., has received an order for all the electrical substation and track-section cabin equipment for the extensions to the Liverpool Street–Shenfield electrification to Chelmsford and Southend (Victoria). The electrification extension covers two sections of main line from Shenfield to Chelmsford on the line to Ipswich, and from Shenfield to Southend (Victoria), a total route of 32 miles. Five 2000kW, 1500V, pumpless steel tank rectifier equipments are to be supplied and will be installed in four substations situated at Hylands, Ramsden Bellhouse, Rayleigh and Prittlewell, the last named being a two-unit substation near the Southend terminal. The a.c. switchgear comprises 33kV, 500MVA and 750MVA, class "MF.36" single busbar equipment; at Prittlewell non-automatic circuit breakers are provided for bus section and incoming isolation. The a.c. switchboard has provision for 30kVA, 33,000/650/415/240V plug-in auxiliary transformers to supply 10kVA, three-phase substation auxiliary and 20kVA, single-phase signal circuits. The 650V supplies for signalling equipment are taken through a Brentford regulating transformer (mounted on the pedestal housing the auxiliary transformer) so as to maintain the signal supply at 650V within the limits of ± 1 per cent. At the three substations from which signalling supplies are taken, the auxiliary transformers are duplicated with suitable change-over facilities. Each rectifier equipment will be designed for twelve-phase operation and comprise two type MB.6/16 rectifiers mounted on withdrawable truck type underbases and housed in separate cubicles. Some of the substations are in residential areas and special low-speed rectifier ventilating fans will be employed to ensure that they operate without undue noise. The 1500V d.c. high-speed circuit breakers are to be truck-mounted "RJR.712" units operated from the track by supervisory control. The four substations and four track-section cabins will be controlled from the existing supervisory control station at Chadwell Heath, where the present Standard Telephones and Cables control desk and equipment is being modified to provide improved facilities and to allow for the new extensions. As main contractor, the British Thomson-Houston Company, Ltd., is responsible for the supply and installation of the whole of the electrical equipment, including the supervisory equipment, batteries, substation lighting, heating and ventilating equipment.

VICKERS-ARMSTRONGS, Ltd., has received an order from Furness Withy and Co., Ltd., for two single screw liners having the following particulars: length between perpendiculars 470ft, breadth moulded 63ft 2in, depth moulded 41ft, draught 29ft 6in, displacement 11,500 tons, service speed 15¼ knots. The turbine machinery of 7700 s.h.p. will be constructed by Parsons Marine Steam Turbine Company, Ltd.

Miscellanea

ASSOCIATION TECHNIQUE MARITIME ET AERONAUTIQUE.—We are informed that the fifty-fourth meeting of the Association Technique Maritime et Aeronautique will be held on May 23rd, 24th, 25th, 26th and 27th at 28, rue Saint-Dominique, Paris, when a total of thirty-three papers will be read and discussed. The annual dinner, presided over by Monsieur Paul Antier, Ministre de la Marine Marchande, will be held on Thursday, May 26th, at the Hotel Lutetia, Paris.

CORRECTION.—In the bibliography to the article "Compressive Stress-Strain Properties of Thin Sheet Material," which appeared in our issue of February 11th, page 191, two of the references were given incorrectly. No. 3 should read, "C. S. Aitchison: 'Extension of Pack Method for Compressive Tests,' N.A.C.A. Technical Note No. 789, 1940," and No. 6 should read "D. A. Paul, F. M. Howell and H. E. Grieshaber: 'Comparison of [Stress-Strain Curves Obtained by Single-Thickness and Pack Methods,' N.A.C.A. Technical Note No. 819, 1941."

DIESEL-ELECTRIC LOCOMOTIVES FOR NIGERIAN RAILWAYS.—The English Electric Company, Ltd., is supplying ten 750 h.p. diesel-electric locomotives for general service on the 3ft 6in gauge system of the Nigerian Railways. These locomotives—which are the first diesel-electric units to be built for this system—will operate singly on shunting and transfer duties, also on the lighter passenger and freight duties, and in multiple unit—under the control of one driver—on the heavier main line duties. These locomotives each weigh 53·15 tons in working order and have a starting tractive effort (25 per cent adhesion) of 30,000 lb, and a one-hour tractive effort at 9·6 m.p.h. of 19,900 lb. Their maximum service speed is 55 m.p.h.

PARSONS CENTENARY FILM.—As part of the proceedings to commemorate the centenary of the birth of Sir Charles Parsons, a film has been produced by C. A. Parsons and Co., Ltd. It was shown to a number of guests at the Criterion Restaurant, London, on Thursday of last week. The film is intended to appeal particularly to students and technicians rather than to professional engineers and is intended for showing in all parts of the world. About the first half of it treats of Sir Charles Parsons himself and the many inventions and discoveries connected with his name, including, of course, the steam turbine and its application to marine power in the "Turbinia" and the development of gearing. Notice is also taken of cavitation experiments, of Parsons' interest in telescopes and the making of lenses and of his attempts to make artificial diamonds and many other things. The latter part of the film covers the present-day activities of the firms he founded.

British Patent Specifications

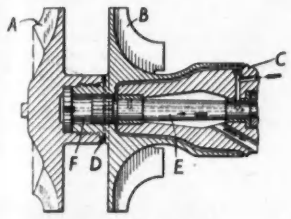
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 6d. each.

BLOWERS AND COMPRESSORS

726,728. April 28, 1953.—Overhung Turbo-blower Rotor, Alfred Johann Buchi, Jun., Alte Römerstrasse 15, Winterthur, Switzerland; and Alfred Johann Buchi, Sen., Salstrasse 20, Winterthur, Switzerland.

The invention is particularly concerned with the problem of properly centring turbine and blower rotors with respect to their means of support and avoiding the transfer of heat from the turbine rotor



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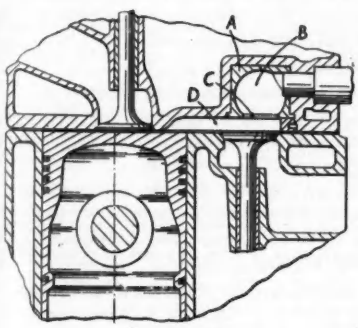
towards the stationary bearing. In the drawing a simple arrangement is shown, in which *A* is the turbine rotor and *B* the blower rotor, while *C* is a stationary bearing which projects partially into the hub section of the blower rotor. The hub surfaces of the two rotors have a releasable connection consisting of an internal thread on the hub of the turbine rotor, and an external thread on the hub of the blower rotor. Guide surfaces shown at *D* serve to centre the two rotors. The hub of the blower rotor has a central bore and a rotor shaft *E* extends through the bearing *C*. Shaft *E* carries at its end a central body *F*, which forms an axial extension within the bore in the blower rotor hub. The design is such that the heat transfer from the hot turbine rotor to the bearing surfaces is small. Auxiliary means can, however, be added to further decrease the flow of heat by cooling the body *F* by spraying cold oil on it through a passage in the stationary bearing, and a spraying nozzle. A modified design embodying this arrangement is also included in the specification.—*March* 23, 1955.

INTERNAL COMBUSTION ENGINES

727,901. March 14, 1952.—Compression-Ignition Engines, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor: Charles Lidiard Jenner.*)

The invention has for an object to provide an improved arrangement of fuel injection, compression-ignition engines. The engine cylinder head *C* is fitted with a series of plugs *A*, one for each cylinder. Each plug has a recess *B* in it in the form of the major part of a sphere and into which the liquid fuel is injected. The recess forms a pre-combustion cell. In accordance with the invention, each plug is so mounted in



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the cylinder head that the pre-combustion cell in it is offset from the axis of its cylinder by an amount such that, when the engine is viewed axially of the cylinder, the pre-combustion cell lies wholly outside the boundary of the cylinder space. The pre-combustion cell has a throat *C* parallel to the axis of the cylinder. The entry to the throat of the pre-combustion cell is connected with the cylinder by means of a duct *D*, which, together with the space above the piston, forms the main combustion space. The duct has its centre line at right angles to and intersecting the axis of the cylinder space. When flowing between the pre-combustion cell and the duct *D* through the throat the gases are required to turn through 90 deg., and the flow produces no substantial directional distribution of the swirl of gases within the pre-combustion cell. The combined volume of the pre-combustion cell, throat and the duct provides more than 50 per cent of the volume of the compression space of the engine when the piston is at top dead centre. An important advantage of the invention is that the engine may be provided with one side valve. Modified designs are also given in the specification.—*April* 13, 1955.

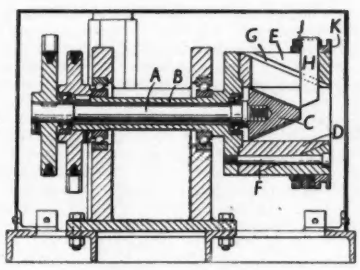
728,133. December 18, 1951.—Lubricant for Two-Stroke Cycle Engines, The Vacuum Oil Company, Ltd., Caxton House, Westminster, London, S.W.1, communicated by the Deutsche Vacuum Oel Aktiengesellschaft, Steinstrasse 5, Hamburg 1, Germany.

It is customary to lubricate two-stroke cycle internal combustion engines by mixing the required lubricant in the fuel. The usual ratios of mixture are approximately in the range 1 : 20 to 1 : 30. In order to assure trouble-free operation of these engines the mixture of lubricating oil and fuel must be sufficiently homogeneous. According to the invention a lubricant for two-stroke cycle engines comprises a lubricating oil and one or more additives adapted to increase the miscibility of the lubricating oil with a fuel, the additive or each additive being a light mineral oil fraction having a boiling range higher than that of the fuel. The ratio of the lubricating oil to the additive or additives is substantially from 2 : 1 to 0·5 : 1, the initial boiling point of the light mineral oil fraction being in the range 365 deg. to 375 deg. Fah. and the final boiling point in the range 660 deg. to 680 deg. Fah., and the initial boiling point of the lubricating oil from 550 deg. to 650 deg. Fah. The lubricant according to the invention possesses the property of mixing easily, quickly and completely with the fuel when added to the fuel in the fuel tank.—*April* 13th, 1955.

MACHINE TOOLS

728,163. October 28, 1952.—Tube Deburring Machine, Helliwells, Ltd., The Airport, Walsall. (*Inventor: John Hewetson Boden.*)

As will be seen from the drawing, two concentric shafts *A* and *B* are mounted in the head of the machine and driven by two pulleys and V belts. At the end of the central shaft *A* is a solid cone-shaped cutter *C*. The outer shaft *B* carries an annular construction consisting of two conical members *D* and *E*, secured together by bolts *F*. The cone *D* has a number of radial slots *G*, in which a series of tools *H* are adjustably mounted by means of a locking ring *J* and



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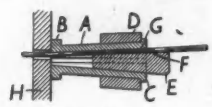
a carrier ring *K*. Means for micrometric adjustment of the cutting tools are provided. In operation the tube to be deburred is fed into the machine so that the internal cutter *C* enters the tube, and the tools *H* are pushed out in their slots *G* until the cutting edges are about equal to the diameter of the tube. The tools are then locked by the ring *J*. When the two shafts *A* and *B* are rotated both the internal and external surfaces of the tube are deburred in a single operation.—*April* 13, 1955.

TENSIONING DEVICES

727,988. April 1, 1952.—Gripping Devices for a Wire Under Tension, Ferroconcrete (Lancashire), Ltd., Woolton Road, Allerton Station, Liverpool, 19; Robert James Shepherd, 1, Danefield Place, Liverpool, 19; and Ernest Charlton, 200, Hunts Cross Avenue, Liverpool.

A particular application of the invention is to gripping devices for releasably holding the ends of high-tensile wire for reinforcement in prestressed concrete. Referring to the drawing, it will be noted that the split lining *A* has a flange *B* at one end and a flange *C* at the other. The outer collar or sleeve *D* is located over the two halves of the split lining and the wedge *E* is inserted in the split lining. This has a longitudinally extending groove *F* so as to provide some space between it and the wedge for the accommodation of the end *G* of the wire. Both halves of the split lining may, if desired, have a longitudinal groove so that the grip can be attached to the ends of two wires located diametrically opposite one another in the grip. The bore of the outer collar or sleeve *D* is tapered to correspond to the taper of the lining *A* and the bore of the lining is tapered to correspond to the taper of the wedge *E*. In the production of pre-stressed concrete the end of the high-tensile wire *G* is passed through the abutment *H*, which may be a steel wall of the mould, and the end of the wire is



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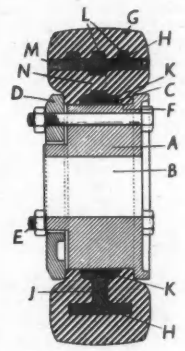
then taken through the lining *A*, the collar *D* is positioned at or towards the larger end of the lining and the tapered wedge is then inserted in the lining and driven hard into it so that the wire end is firmly gripped between the wedge and the lining. The wire is then placed under tension and a similar gripping device is applied to its other end so as to maintain the wire under tension. To release the device it merely becomes necessary to drive the outer collar *D* towards the opposite end of the lining.—*April* 13, 1955.

ROAD TRANSPORT

728,008. November 26, 1952.—Vehicle Wheels and Tyres, The A.P.V. Company, Ltd., Northfield House, Wandsworth Park, London, S.W.18; Charles Jean Leonard Boisselot, 5 bis, Rue Joseph Bara, Paris; and Leonard Emile Boisselot, 102, Rue des Marguerites, Antony, France.

The invention relates to tyres for wheels for vehicles in which the rubber tyre is reinforced by a metal ring which is embedded in the rubber and which has an extension which passes from the ring to the level of the radially inner surface of the tyre, at which place the extension provides a metal surface to seat directly on the rim of the hub of a wheel. Referring to the drawing, the wheel includes a heavy cylindrical hub *A* which is formed with an axle-receiving hole *B*. The hub has on one side a projecting tyre-retaining flange *C*, and on the other side a removable flange *D*. The tyre comprises a rubber ring *G* which is reinforced or strengthened by an embedded metal ring *H* having an extension or web *J*, the hole being of T-shaped cross-section; the extension extends to the inner surface of the rubber ring, where its own inner surface *K* lies flush with the inner surface of the rubber ring and provides a metal surface to rest directly on the surface *F* of the hub of the wheel, the metal section being otherwise embedded in the rubber. As is shown, the web *K* is flanged to provide an area of contact with the hub. The metal ring has on its periphery numerous radial projections, such as *L*, and, in a lesser number, lateral projections, such as *M*. These are provided for the purpose of holding the metal ring to the rubber, for which purpose also the web *J* of the ring is pierced by a series of holes *N*. The formation of the strengthened tyre, according to the invention, is effected by the direct pouring of the rubber on the metal ring *H* so that it is, except for the inner surface of the web *J*, surrounded by the rubber which encircles the radial and lateral projections respectively.—*April* 13, 1955.



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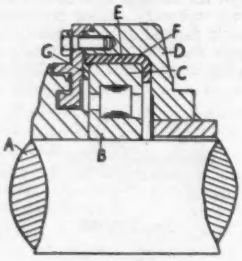
ELECTRICAL ENGINEERING

722,061. July 4, 1952.—Electric Locomotive Motor Bearing Arrangements, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, and William Emlyn Lewis, of The General Electric Company, Ltd., Engineering Works, Witton, Birmingham.

The invention relates to bearings of electric motors for electric railway locomotives or other vehicles. As shown in the drawing, the motor is supported on an axle *A* by ball or roller bearings, the inner members *B* of which are a press fit on the axle. Insulation is interposed between the outer members *C* of the bearings and the structure *D* supporting them so as to avoid an electrical connection between the outer members of the bearings and the supporting structure *D* which may be the stator frame of the motor. This insulation is provided by an anodic layer formed over the entire surface of an aluminium bush *E* surrounding the outer member *C* of each

bearing and an aluminium ring *G* with a similar anodic layer. The aluminium bush is housed in a recess *F* surrounding the bearing. In another arrangement, the structure *D* supporting the bearings



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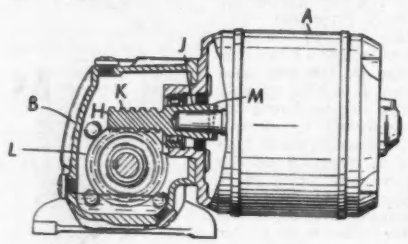
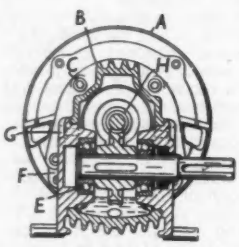
is constituted by an aluminium casting and the surface layer is formed on this casting itself by anodic treatment. In a further arrangement, the surface layer is formed by a phosphate treatment of a steel part.—*January* 19, 1955.

727,325. May 9, 1952.—GEARED MOTOR UNITS, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventors: Edward Stewart Lowley and Alfred Geoffrey James.*)

Referring to the drawing, the electric motor *A* is secured to the ribbed gearbox *B* by means of bolts *C*, the output shaft of the gearbox being journalled in bearings *E* mounted in bearing housings *F*. Mounting feet are formed integral with the bearing housings, which are each secured to the gearbox by means of four bolts *G* equally spaced on the same pitch circle and arranged so that the motor can be mounted on either a horizontal or a vertical axis relative to the feet. By reversing the relative positions of the two bearing housings the output shaft can also be arranged to project from one side or the other of the gearbox. The worm *H* has an unthreaded part *J* and a threaded part *K*, only the unthreaded part being bored to receive the taper motor shaft. The worm meshes with a worm wheel *L* and the unthreaded part *K* is arranged to constitute the inner race of the motor driving end bearing which is mounted on an extension integral with the driving end motor endplate. The





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worm is formed from case-hardened steel and is secured to the shaft by means of a taper dowel *M*. The worm wheel *L* is secured to the output shaft by means of a key and is arranged to dip into the gear oil. Drain plugs are provided for draining the oil from the gearbox and a breather plug is also provided. Shaft seals seal the interior of the gearbox from the motor and from the atmosphere respectively. It will be seen that the pitch diameter of the worm *H* is appreciably less than the minimum pitch diameter which would have been possible if the worm had been bored to receive the motor shaft throughout its full length. It will also be seen that the bearing lies immediately adjacent the threaded part of the worm.—*March* 30, 1955.

KWINANA REFINERY.—At the 3,000,000 tons per year refinery of the British Petroleum Company, Ltd., at Kwinana, Western Australia, a "hydrofiner" has been built and commissioned and the company state that similar units are to be built at the Kent and Hamburg refineries.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

HORIZONTAL MILD STEEL WELDED STORAGE TANKS

No. 2594 : 1955. Price 4s. This standard relates to the design and construction of mild steel fusion-welded horizontal storage tanks with dished and flanged ends complying with Table 4 of B.S. 1966, "Domed Ends for Tanks and Pressure Vessels," and to tanks with unflanged outwardly dished ends. The sizes of tanks range from 3ft 6in diameter by 4ft nominal length up to 9ft diameter by 30ft nominal length.

It specifies requirements for tanks of adequate safety and reasonable economy, in a range of sizes to suit the requirements of user industries. These tanks are intended for the static storage of liquids which are not corrosive to mild steel. The tanks are classified by dimensions instead of by capacities, which has hitherto been the practice in the trade. As a guide to the user the gross capacities of these tanks are given in the tables.

Tanks with flat ends and tanks with inwardly dished ends are not provided for, and the standard does not relate to tanks on transport vehicles or to lined storage tanks.

UNIVERSAL DECIMAL CLASSIFICATION

No. 1000 (622/623) : 1955. 622, Mining and Mineral Dressing ; 623, Military and Naval Engineering. Ordnance arms production. Price 15s. This is a new section of the English Edition (4th international edition) of the Universal Decimal Classification, which is being published in parts by the British Standards Institution as B.S. 1000. It contains the full classification schedules, revised from the 2nd and 3rd international editions in French and German, together with separate detailed alphabetical indexes, for the two major fields of mining and mineral dressing, and military and naval engineering.

It is pointed out that the two subjects, though not especially related, together form a convenient fifty-page volume, shortly to be supplemented by the remaining sections of sixty-two (engineering). It is believed that these new schedules will be useful for all workers in these fields with any substantial technical literature to classify, especially if used in conjunction with the abridged English edition of the whole U.D.C., B.S. 1000 A, of which a second revised edition will be published later this year.

FLEXIBLE POLYVINYL CHLORIDE (PVC) EXTRUSION COMPOUNDS

No. 2571 : 1955. Price 5s. This standard applies to certain polyvinyl extrusion compounds supplied as material for the manufacture of various products. It is pointed out that, in some cases, the products, e.g. electric cables, for which these compounds may be used, are covered by other British Standards, in which quality is controlled by tests made on the finished product. The use of compounds complying with this standard does not necessarily ensure compliance of a fabricated article with the standard appropriate to such an article. It specifies three classes of compound as follows :—Class 1, compounds with specified electrical properties and having a volume resistivity not less than 10^{12} ohm-cm at 23 deg. Cent. Class 2 : compounds with specified electrical properties and having a volume resistivity not less than 5×10^{8} ohm-cm at 23 deg. Cent. Class 3 : compounds for which the electrical properties are not specified. Each of these classes is subdivided into types so that in all twelve types of compounds are provided for.

GLOSSARY OF ACOUSTICAL TERMS

No. 661 : 1955. Price 6s. This is a revision of the "Glossary of Acoustical Terms," first issued in 1936. The advance of techniques in the fields of acoustics since that date has rendered necessary many changes in the contents and arrangement of the new edition, and about eighty new terms have been added (an increase of about 40 per cent). The main changes are : the enlargement of the section on recording and reproduction to keep pace with techniques, particularly that of using magnetic tape and wire, which are finding applications in many fields, and the inclusion of a new section which mirrors the emergence of ultrasonics from laboratory demonstrations to varied industrial applications. A section on the subject of underwater sound, which, in 1936, was mainly limited to naval application, has been included. The first edition contained a number of musical terms (e.g. common chord, melody), which have now been deleted on the grounds that they are more appropriate to the art of music than to the engineering and physics aspects of the subject. The section headings in the new editions are as follows :—Fundamentals ; Propagation ; Hearing ; Transmission Systems ; Ultrasonics ; Underwater Sound ; Instruments ; Recording and Reproduction ; Music ; Architectural Acoustics.

ACCEPTANCE TESTS FOR SINTERED METAL POWDER COMPONENTS

No. 2590 : 1955. Price 3s. This standard makes recommendations with regard to the sampling and testing of the finished sintered component as distinct from the metallic powder from which it is made, for which other British standards are in course of preparation. It also makes recommendations with regard to the test pieces to be used for mechanical testing, as the normal British standard test pieces designed for metal products are not suitable for the small components to which the recommendations of this standard apply.

GIRDER BRIDGES

No. 153 : 1954 : Part 3A, Loads. Price 6s. The full revision of B.S. 153, which was started several years ago, will take a further time, and agreement having been reached on the revised loading requirements, it has been considered advisable to issue this section forthwith. It supersedes clauses 1 to 12, of B.S. 153, Part 3 : 1937, which have been withdrawn by the issue of Amendment No. 2 of that part. The "Tables of British Standard Unit Loading for Railway Girder Bridges and Highway Bridges" has also been superseded by the newly issued Part 3A. The major changes are revisions of the highway and footway loadings, railway impact effects and the treatment of wind pressure.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

CHEMICAL SOCIETY

Thurs., June 2nd.—CENTENARY LECTURE : Burlington House, Piccadilly, London, W.1, "Chemical Effects of Steric Strains," H. C. Brown, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

Thurs., May 26th.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, "Illumination," 7.30 p.m.
Fri., May 27th.—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, "Steam in Industry," L. A. Bawden, 7.30 p.m.
Tues., June 7th.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, A talk on Work Study by a member of the British Productivity Council, 7 p.m. ——MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, Open Meeting, 7.15 p.m.
Thurs., June 9th.—N. E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "Steam for Process," L. G. Northcroft, 7 p.m.

INSTITUTE OF INDUSTRIAL ADMINISTRATION

Wed., May 25th.—LONDON BRANCH : Fyvie Hall, The Polytechnic, Regent Street, London, W.1, "The Practice of General Management : Application of Scientific Research," A. King, 6.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., May 24th.—SPECIAL MEETING : Royal Institution, 21, Albemarle Street, Piccadilly, London, W.1, "Mechanism of Fluidization of Powders in Gases," Warren K. Lewis, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 24th.—ORDINARY MEETING : Great George Street, Westminster, London, S.W.1, James Forrest Lecture : "Nuclear Power and World Energy Resources," Sir John Cockcroft, 5.30 p.m.
Tues., June 7th.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., May 26th.—Geological Society, Burlington House, Piccadilly, London, W.1, Annual General Meeting (Corporate and Non-Corporate Members only), 4 p.m.; Presentation of Awards, Induction of New President, Stanley Robson, Presidential Address, 5.15 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., June 9th.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "The Influence of Dimensions on the Behaviour of Partial Superstructure," W. Muckle, "The Strength of Corrugated Plating for Ships' Bulkheads," J. B. Caldwell, 4.45 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., May 25th.—SHREWSBURY SECTION : Technical College, Shrewsbury, "Manufacture of Springs," J. A. Roberts, 7.30 p.m.——WOLVERHAMPTON SECTION : Technical College, Wolverhampton, Practical Approach to Engineering Fine Surfaces," D. B. Ebsworth, 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., May 26th.—11, Upper Belgrave Street, London, S.W.1, Annual General Meeting, 6 p.m.

INSTITUTION OF WATER ENGINEERS

To-day, May 20th.—Richmond Hill Hotel, Richmond, Surrey, Sixtieth Summer General Meeting.

ROYAL STATISTICAL SOCIETY

Wed., May 25th.—ORDINARY MEETING : School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "A Unified Derivation of Some Frequency Distributions of Importance in Biometry and Statistics," J. O. Irwin, 5.15 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Fri., June 3rd.—Cafe Royal, Regent Street, London, W.1, Annual General Meeting, 6.15 p.m., Annual Dinner, 7.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., June 8th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, Annual General Meeting and Film Show, 6.45 p.m.